S. Hrg. 102-765

EFFECTS OF THE ACCIDENT AT THE CHERNOBYL NUCLEAR POWERPLANT

HEARING

BEFORE THE

SUBCOMMITTEE ON
NUCLEAR REGULATION
OF THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED SECOND CONGRESS

SECOND SESSION

JULY 22, 1992

Printed for the use of the Committee on Environment and Public Works

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EFFECTS OF THE ACCIDENT AT THE CHERNOBYL NUCLEAR POWERPLANT

WEDNESDAY, JULY 22, 1992

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON NUCLEAR REGULATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:41 a.m. in room 406, Dirksen Senate Office Building, Hon. Bob Graham [chairman of the subcommittee] presiding.

Present: Senators Graham and Lieberman.

OPENING STATEMENT OF HON. BOB GRAHAM, U.S. SENATOR FROM THE STATE OF FLORIDA

Senator GRAHAM. Good morning. The Subcommittee on Nuclear Regulation will come to order.

Today the subcommittee will examine the effects on public health and environment of the accident that occurred at the Chernobyl nuclear plant in April of 1986. We will also use this as an opportunity to examine what needs to be done with the aftereffects of Chernobyl and what should be United States international policy relative to Soviet-designed nuclear plants in the former Soviet Union and other parts of the world.

The explosion of the reactor at Chernobyl led to the largest single-source release of radiation into the atmosphere that has ever been recorded. The accident released approximately 50 times more radioactivity than was released by the atomic bombs at Hiroshima and Nagasaki. The radioactive fallout from the Chernobyl accident has affected millions of people.

According to the official statistics of the former Soviet Union, at least 31 fire fighters and plant operators died within days of the accident from high radiation exposure. There is considerable evidence that the actual death toll from acute immediate exposure was much higher. Hundreds of thousands of persons who lived within 30 kilometers of the accident were evacuated from their homes. They never were able to return. Over 600,000 army soldiers and miners were brought in from all over the former Soviet Union to stabilize the damaged reactor in the days and months following the accident. Many of these liquidators received doses comparable to the doses received by the survivors of the bomb blast at Hiroshima and Nagasaki. Some may have received much more.

Several million people continue to live in areas that received significant radioactive fallout from the accident. For several years in

many areas, an individual's average exposure to radiation was twice the normal exposure before the accident. The subcommittee today will examine the effects of the Chernobyl accident upon all of these people. We will look at the studies that have been done and ask what additional studies need to be done.

In addition, we will hear testimony about the continuing danger posed by the Chernobyl reactor. The concrete structure surrounding the damaged reactor that was constructed after the accident is sinking and cracking. The core, filled with thousands of tons of sand and concrete, also is sinking. There is a danger that additional radioactivity may be released from the damaged unit into the atmosphere or into ground water.

Finally, we will ask what the needs and opportunities are for providing assistance to the Ukraine and other affected states. I hope that our witnesses can provide the Congress with suggestions as to the most effective way that we can provide aid to the people in need.

I would like to thank Senator Lieberman for his leadership in suggesting this hearing and I commend him for all of his efforts and assistance in bringing this matter to the attention of the subcommittee. I hope that the efforts of the Senator and the subcommittee can help bring some of the needed relief to the tragic victims of this nuclear disaster.

Senator Simpson, the ranking member of this subcommittee, was unable to attend today's hearing. His statement will be included at this point in the record.

[Senator Simpson's statement follows:]

STATEMENT OF HON. ALAN K. SIMPSON, U.S. SENATOR FROM THE STATE OF WYOMING

Thank you Mr. Chairman for holding this hearing on the health effects resulting from the tragic accident at Chernobyl unit number four in April 1986—now six years ago. The three hearings this subcommittee has held on the safety of Soviet designed reactors, helped shape the comparable amendments offered by the Chairman, myself and others to the Freedom Act—the Soviet aid bill.

Our amendments will provide immediate assistance to improve the safety of the operating nuclear plants and, in the longer term, to assess all energy options to shut down the operating RBMKs and older VVER reactors.

The Chairman and I are acutely aware of the design deficiencies of the RBMK graphite reactor and the tragic consequences of the Chernobyl accident.

The most significant deficiency of this design is the lack of western-styled containment—the massive steel and concrete structure which is the final barrier against large releases of radiation in the event of an accident.

Unlike U.S. commercial light water reactor fuel, the graphite used in the RBMK reactor can burn and inadequate fire-protection systems are useless in such an event.

The RBMK nuclear chain reaction is faster and in the event of coolant water loss, becomes unstable and accelerates. at Chernobyl, the RBMK core experienced such a power increase called "positive void coefficient" which contributed to the accident.

Soviet engineers have sought to modify this tendency by backfitting RBMKs with faster-acting control rods and other fuel design improvements.

It is interesting to note that U.S. nuclear plants are designed with "a negative void coefficient" so that the chain reaction naturally diminishes in the event of cooling water loss.

The RBMK design does not include redundancy of electrical and safety systems in the event of maintenance failure or accident, nor are these systems separated from one another so that the same failure does not affect the redundant system—these are safety characteristic of U.S. plants.

The list of problems goes on—complicated piping designs, poor quality control and quality of construction and so on.

It is clear that the remaining RBMK reactors—which are located in the Republics and Lithuania—should be shut down as soon as economically and practically feasible.

The Ukrainian Parliament vote in 1991 to shut down the two operating RBMK reactors at the Chernobyl site is a welcomed decision.

Regarding the issues to be investigated at today's hearing, I am very interested to learn of the witnesses opinions on the continuing health impacts of the 1986 Chernobyl accident which resulted in huge releases of radioactive material to the environment and excessive exposure to the countless unknown.

The IAEA's initial effort to assess the health impact of the Chernobyl accident is to be applauded. we have come to understand that their effort was an immensely difficult one in the absence of reliable data.

Obviously, continuing research to assess the longer term affects of exposure from the accident is needed.

I look forward to learning of the ways in which U.S. technology and expertise in the area of decommissioning and decontamination may be exported to benefit the citizens of Ukraine.

Thank you for holding this hearing, Mr. Chairman, on the very important issues of assessing the health impacts of the Chernobyl accident and exploring ways in which this country may provide help and assistance to the people of Ukraine.

Senator GRAHAM. We will hear today first from a panel composed of scientists with special background in the consequences of Chernobyl. Dr. Zenon Matkiwsky is the President of the Children of Chernobyl from Union, New Jersey. Dr. Wladimir Werteleckyj is Professor and Chairman of the Department of Medical Genetics at the University of South Alabama. He is the acting coordinator of the American-Ukrainian Medical Sciences Group. Dr. Fred Mettler is Professor and Chairman of the Department of Radiology at the University of New Mexico and has studied the health effects as the team leader on the International Chernobyl Project. Dr. Edward E. Purvis, III, is Senior Engineer of the Los Alamos Technical Associates. Dr. Murray Feshbach is Research Professor in Demography of the Department of Demography of Georgetown University.

As has been our practice, our hearing will be conducted in this round-table fashion. I would ask each of you to make an opening statement of approximately five minutes, your full statement will be part of the record, and then we will commence with questions and discussion among our panelists.

First, Dr. Matkiwsky. Would you please pronounce your name?

Dr. MATKIWSKY. Matkiwsky.

Senator GRAHAM. Thank you very much, Doctor.

STATEMENT OF DR. ZENON MATKIWSKY, PRESIDENT, CHILDREN OF CHERNOBYL, UNION, NEW JERSEY

Dr. MATKIWSKY. Thank you, Senator and ladies and gentlemen. Our foundation is grateful to the committee for giving us the opportunity to present this testimony.

It has been six years since the accident of the Chernobyl nuclear station. This tragedy has inflicted irreparable damage on some of the most fertile and productive territories of Ukraine and Byelorussia. It is also expected to have a profound effect on the ecology and economics of many other nations. Tremendous costs have been expended on the containment of the disaster's aftereffects. Given the depth of its economic crisis, Ukraine cannot cope with this massive problem alone. For a nation which has just achieved its independence, Chernobyl has imposed a tremendous and crippling burden.

In recent months, a great deal of new evidence has come to light showing that Soviet authorities engaged in an extensive coverup of the immediate effects of the Chernobyl accident. The deceit surrounding the accident at Chernobyl was as global in scope as the nature of the catastrophe itself. As journalists in Moscow and Kiev have gained access to newly-declassified documents, they have learned that not 34 but as many as 8,000 persons, mostly nuclear cleanup workers, have already died as a result of radiation exposure in Chernobyl.

We now know that in the spring of 1986, the Politburo was receiving daily updates on thousands of cleanup workers and children who were hospitalized with radiation sickness even while publicly Soviet officials were telling the world that the health impact was negligible and grossly exaggerated by the western press. An article published last April in Izvestiya reveals excerpts from secret protocols of Politburo which directly contradict the public pronouncement of Soviet authorities.

Beyond the immediate impact, some scientists speculated that additional deaths resulting Chernobyl would be too few in number and too dispersed in the population to detect. But the real long-term tragedy of Chernobyl is just beginning to unfold, and already the results are not only detectable, they are quite stark indeed.

The Ukrainian Ministry of Health has reported a tripling of cancers among Ukrainian children since 1986. Most disturbing among these is the sharp increase in thyroid cancer among children. The number of operations performed on children with thyroid cancer has risen from an average of two per year to 20 in 1990, 30 more in 1991, and now, after only the first five months in 1992, the incidence of new thyroid cancer stands at 52. Our own national institute of health has expressed grave concern about the growing number of confirmed reports of thyroid cancer among small children in northern Ukraine and southern Byelorussia.

In the hospitals sponsored by our foundation, hematologists have also noticed a dramatic increase in the number of new leukemia cases diagnosed since 1990. The number of congenital malformations among newborns throughout the republic has gone up from 13,000 in 1985 to 14,400 a year between 1987 and 1990. There is also growing evidence of extensive chromosome changes and the potential for long-term genetic damage affecting persons living in the Chernobyl region. A highly detailed study of German citizens returning from the vicinity of Chernobyl following the 1986 accident has documented a dramatic increase in structural chromosome aberrations.

The dramatic health situation which is unfolding in Ukraine is disputed by the health commission formed by the International Atomic Energy Agency, which was invited by the government of the former USSR to analyze various issues associated with the Chernobyl accident. The commission was composed of authoritative scientists and we give acknowledgement to their qualifications. However, the commission was faced with constraints on cost, time, and necessary equipment, and these conditions forced this team of scientists to rely in part on information provided by the Soviet government. The discrepancy between the data offered to the IAEA

and the information contained in the Kremlin secret files led to some regrettable conclusions. Let me just cite the following:

In October of 1991, six months after the IAEA report was completed, the Federal prosecutor of the USSR addressed the sale of 47,000 tons of meat and two million tons of milk products which came from contaminated territories over a three-year period. The radioactivity of these products exceeded by several hundred-fold the maximum permissible limits on cesium established by the IAEA. Not knowing these facts, the advisory committee accepted the conclusion that "Doses actually received due to the ingestion of contaminated food stuffs were substantially lower than the prescribed intervention level, and food stuffs may have been restricted unnecessarily."

The IAEA researchers cited radiophobia and psychological stress as possible explanations for the reports of increased cancers and more serious health effects. But we need to remember that radiation illness was not even permitted as a medical chart diagnosis in Ukraine for the first years after the accident. Any speculation about radiophobia and the alleged exaggeration of health effects need to be considered against the backdrop of the indisputable coverup of Chernobyl, which for six years severely undercounted radiation effects and falsified the medical history of Chernobyl's earliest victims.

Another common misconception about Chernobyl is the notion that we can extrapolate the number of latent cancers from those that occurred after the atom bombs were dropped in Hiroshima or Nagasaki. Such estimates ignore the fact that Chernobyl may have released the equivalent of 100 Hiroshima bombs, water cesium, and other isotopes. Given the increase in lung cancers noted by the Ministry of Health, there is also a need to address the problem of so-called radioactive hot spots which can affect the lungs and lymph nodes. The IAEA study also did not address the synergistic effect of radiation and other pollutants.

In conclusion, we are observing a precipitous decline in the state of health of the Ukrainian population. We need to remember that the IAEA study never examined the highest-risk population, namely the 600,000 nuclear cleanup workers and the 200,000-plus evacuees from the excursion zone. To make matters worse, health experts do not expect the bulk of the cancers and latent health effects from Chernobyl to occur until 10 to 15 years after initial exposure, when the latency period for strontium, cesium, and other isotopes have tolled.

Under the circumstances of the current economic crisis, Ukraine will need intensive monitoring by health experts for at least 20 years, and it will need much more substantial aid from the West. With growing urgency, the Ukrainian Parliament and the Council of Ministers have issued official appeals for aid from western nations. They have gone out of their way to express their gratitude to those who have already provided aid. We are providing copies of such pleas for assistance.

The recommendations that we propose are the U.S. Government should increase and distribute medical aid to the newly independent states so that a greater portion flows to the three northernmost provinces of Ukraine, namely Chernihiv, Kiev, and Zhitomir, which

were hardest hit by radiation from Chernobyl. Additional funds need to be appropriated to the Department of Energy and National Institute of Health and other agencies to research on radiation health effects, and funds which have not yet been spent need to be devoted to the following projects in the Chernobyl region:

A long-term health study of the population which was not examined by the IAEA team, namely the nuclear cleanup workers and some of the 200,000 evacuees from Chernobyl, who run the highest risk of latent cancers and other health defects. Followup studies also need to be done on the general health of people living in regions contaminated by low-level radiation, Zhitomir Province and the Polissia region in Kiev Province in particular. The IAEA team did not have the opportunity to look into the effects of radioactive hot spots, and a program needs to be established for the analysis of this problem.

Followup studies are needed to determine the extent of chromosome aberrations and long-term genetic damage among children in Kiev and Polissia using so-called biological dose symmetry. There is also a need for further investigation of reports of genetic deformation in animals and newborn children. A comparative study of thyroid cancer incidence in children and assistance in the establishment of a nationwide cancer registry in Ukraine and Byelorussia. Research on the synergistic effect on radiation and other forms of pollution. Example: a study of the combined effect of exposure to radiation and heavy metals, such as cadmium, or a comparison of the health condition of coal miners from the Donetsk region who were sent to Chernobyl for cleanup duties in 1986 as compared to the health of miners who were never sent to Chernobyl.

Assistance for the underfunded Ukrainian Environmental Health Project based at the University of Illinois which examines the health of mothers and children in Kiev and the four other Ukrainian cities. Our government needs to offer incentives to U.S. pharmaceutical firms and hospital supply companies to invest in Ukraine to help rebuild the country's medical infrastructure and to benefit from opening a new market in the important region. We would recommend the creation of a scholarship fund for specialists from Ukraine to be trained in the U.S. using American medical equipment and procedures.

Most importantly, the West needs to help prevent future Chernobyls by providing engineering technology and technical assistance for the rapid decommissioning of the RBMK-model reactors which continue to pose an ongoing threat to the health and safety of Ukraine and its neighboring countries. The West should promote energy conservation and renewable energy technologies to help reduce Ukraine's dependency on RBMK reactors and other environmentally destructive sources of energy, such as coal.

Finally, we would encourage cooperation between Ukraine and American nuclear experts to develop short-term solutions to the contamination hazard posed by RBMK reactors. In particular, we would like to see the Department of Energy explore innovative laser techniques being developed by United Technology, such as in Connecticut, which would allow nuclear cleanup workers to remedy the problems of Chernobyl by remote control, without further exposure to radiation hazards.

With growing urgency, the Ukrainian Parliament and Council of Ministers have issued pleas to the United States for the type of assistance recommended above. Ukrainians have gone out of their way to express gratitude for the aid that has already been given. The Children of Chernobyl Relief Fund looks forward to working with this committee to help create a healthy and safe environment for the children of Ukraine and the children of the world.

I thank you very much.

Senator GRAHAM. Thank you very much, Doctor.

Next, Dr. Fred Mettler, Health Effects Team Leader for the International Chernobyl Project.

STATEMENT OF DR. FRED A. METTLER, JR., PROFESSOR AND CHAIRMAN, DEPARTMENT OF RADIOLOGY, UNIVERSITY OF NEW MEXICO, AND HEALTH EFFECTS TEAM LEADER OF THE INTERNATIONAL CHERNOBYL PROJECT

Dr. METTLER. Thank you. It's a pleasure to be here.

I would start out by reiterating at least one comment of the previous speaker, and that is that the health effects are generally divided, one would think, among four broad groups of people: the firemen and workers at the plant at the time of the accident, of whom, as you indicated, about 31 have died, but overall or at least between 150 and 300 who suffered from what is known as acute radiation syndrome.

Then the liquidators or the emergency accident workers, and again, as you indicated, the numbers are probably in the range of 600,000 to 700,000 people. Those people are spread across about 12 time zones right now, making it moderately difficult to study them. Many of those people also came to the plant as nuclear power plant workers from other areas, and data has now come out that many of those people had substantial exposures before they ever got to Chernobyl, and what effect that will have is not at all clear.

A third group are the people who, you indicated, have already been evacuated, and again, many of those have been sent to fairly distant locations. In our travels, we did look around for records on those people to see if we could locate them, and in fact, the records that we found were only fragmentary, so we weren't sure it was going to be easy to locate them and/or go to where they were to study them.

I would say that the groups just that I've enumerated constitute probably a million people. You need to remember that at Hiroshima and Nagasaki, we have been studying essentially with U.S. funding about 80,000 people, survivors of the atomic bombing over the last 45 years. That effort alone has cost us billions of dollars over the years to study 80,000 people. The group involved here is coming up on a million exposed people, and if one were going to study them, you would need probably a million or two million controls to study over the next, legitimately, 40 to 50 years. So I think the costs of that are really staggering when one thinks about it.

The fourth group of people exposed is the general public, and that is in fact the group that the former Soviet government asked us to look at. We were aware at the time, and so was the Soviet government, that other groups may, and did, receive substantially

more exposure. However, their exposures had ended, and the people living in villages in contaminated areas had exposures that were continuing, and the former Soviet government was particularly interested in what they should do for actions in order to deal with continuing exposures. The other ones they felt that at least at that point there was no action to be taken to remediate them or reduce them. So we in fact were sent out with a specific mission of looking at the general public. The reason we didn't look at the other groups was we weren't asked to, and they understood the problem as well as we did.

Now, two other groups had gone to the Soviet Union before the International Chernobyl Project, and those were groups from the World Health Organization and from the Red Cross or Red Crescent. They had spent several weeks pretty much on a fact-finding mission traveling around in 1989 and concluded at the end of that that they did not see any effects that they could determine as being radiation effects at that particular point, but they were worried about long-term cancers and leukemias and things like that. However, there were a large number of reports both from the media and from Soviet scientists which were conflicting and didn't fit in with what was known about radiation biology, so an international group was asked to come in and do a much more detailed study.

That group had five portions or teams. One was a historical group to look at records, the second group was to look at environmental sampling, and in fact, they did go to villages and take thousands of milk samples and food samples and so on to check to see whether the Soviet numbers were in fact correct. A third group went in to look at dosimetry—that is, what dose the people were actually getting who are living in those villages. That group actually brought in equipment from France and ended up measuring over 10,000 people to determine how much cesium was in fact in their bodies. It was not always germane to find out what's in the food; it's really what are they getting in their bodies. So they did that to 10,000 people. They also took about 5,000 what we would call film badges and had people carry them around in the different villages. The fourth group was the one I was asked to lead, which was the health effects group, to look at what the health of the people was, to locate Soviet data that had been obtained and critique it, and then to finally go to villages and see what we thought the health was and compare it to places which were essentially clean.

During 1990, our teams made 11 trips to the Soviet Union and involved 50 physicians from over 15 different countries. Only six of those physicians were in fact from the United States. They came from Argentina, Australia, Greece, and so on. We ended up spending several months in the Soviet Union traveling around to the institutes looking at data that scientists had collected, and we interviewed for an hour each over 100 scientists. We brought back in experts from various countries in those specific areas later on, and they were re-interviewed, and their original data was looked at as opposed to the results. Then we traveled to several of the highest-contaminated villages we could find—two in the Ukraine, three in Byelorussia, and two in Russian Federation—and then we went to clean villages in those regions relatively nearby to have a comparison between the groups.

We did check soil samples and radiation measurements in the "clean" villages to make sure that they were in fact clean. Our findings were that when we reviewed data of Soviet scientists, some of it in fact was quite well done. However, many of the studies we looked at were conflicting internally. That is, a study would find one thing one year, the effect wouldn't be there the next year, and it would be back the third year. And, of course, most radiation effects aren't interested in the calendar, and they don't know when January comes and goes. So there were internally conflicting data.

Generally very few of the scientists had used control groups. That is, they had gone to a contaminated village and studied it, but they hadn't gone to a clean village and looked to see what was going on there. Often we were given percentages of findings without the real numbers, and the real numbers were very hard to come by often. Quality control generally was not practiced. The equipment rarely had standards performed in the morning and so forth, and in many cases that was understandable, because they didn't have access to the standards which we would normally have in this country.

We saw a lot of unused equipment, equipment that had been donated by the United States and private donors, which was sitting unused because they didn't have the reagents to make the equipment run. We saw equipment unused because one small part was broken and they couldn't get the piece to fix it. We saw resources wasted by very well-meaning scientists because they did not have access to literature. They did not know that those things had been studied in the past with either positive or negative results. And we saw a lack of scientific cooperation between republics and between scientists often in the same institute who were not interested in sharing data.

We did see a lot of concern among the public both in clean and contaminated villages. About 90 percent of people that we interviewed in highly contaminated villages thought they had or thought they might have an illness due to radiation. The number in perfectly clean villages was about 75 percent of the people. So even if you went to a place outside of those areas that are marked as contaminated on that map, 75 percent of the people think they have or might have an illness due to radiation.

The dosimetry estimates based not on the food intake particularly, but based on what cesium was actually in people and based on the film monitors that they were carrying around, over the last five years ended up being about three rads total radiation dose. That's about the equivalent of one CT scan, or computed tomography scan. Those people in fact, to get that dose, were living what I would call non-normal lives. They were looking at what food they were eating, and they were restricting contaminated foods from coming into their houses. They knew what spots in their village had a lot of cesium, and they were walking around them. So they were able to keep their doses reasonably low, but certainly not by maintaining a normal lifestyle.

The claims of stillborns and malformations increasing in fact are not supported by any of the data that we saw. If one looks at some of the data which I have supplied to you, the official data from the Byelorussian Ministry of Health in 1990 indicates that registered

malformations in the contaminated regions of Byelorussia was 4.3 per thousand in 1986 and was 5.3 in 1989 and in fact 7 in 1988. So if one looks at 1986 to 1988 and 1989, it looks like it's going up. However, if you go back and look at the data from 1980 and 1981, you see numbers of 6 and 5.8 and so forth. So one needs to look at the whole span of the actual data that one has. In addition, if one looks at stillborns from the official data, you get 7.2 in 1986, 7.5 in the year after the accident. However, in 1981 it was 7.6, higher than either the year of the accident or the year after. So the data has to be looked at very carefully.

We did look at issues of immune deficiency as they were brought up. One looks at that by looking at the incidence of viral abnormalities, hepatitis, measles, all sorts of things, and the official data has been given to your staffs and, again, does not support the contentions of a general decrease in immune level.

The media had reported anemias and large thyroids. These are things which generally are not reported in other radiation environments, and in fact, the red blood cell is relatively resistant to radiation. We did find children and adults with enlarged thyroids and with anemia. We did not find more than we would have expected in other countries nor was it different from the clean areas. We did look at nutrition and growth of the children, and both in contaminated and clean areas it's running right down the 50th percentile of U.S. and USSR norms. So that nutrition appeared to be adequate. Thus, our data concerning acute radiation effects seems to be consistent with data that has been accumulated in other accidents and other studies in other places.

The psychological issues that were brought up by the previous speaker that the Project found, radiophobia—is wrong. In fact, the findings, if one reads the technical report, are that we did not feel there was radiophobia. We did feel there were psychological aspects, but the people were trying to deal with living in a radiation environment. I can tell you that when we asked people if they were so fatigued they didn't want to get up in the morning, 89 percent in contaminated villages said yes versus 81 percent in clean villages. We asked about headaches. Eighty-one percent reported them in the last three months in contaminated villages versus 77 percent in clean villages. We asked about chest pain. It was 53 percent in contaminated villages and 43 percent in clean villages. So there was a slight increase, but all the numbers are much, much higher than one would expect normally.

There have been studies done on children besides our study. There have been 3,000 children sent to Cuba, for example, and the conclusion of the Cubans was that they in fact did not see any radiation effects in those children. Children have also been sent to France and to Germany with fairly similar findings.

Now, regarding the issues of thyroid cancer and leukemia, we looked at those very seriously, because we did expect that might be a problem and we did expect that one could see leukemia this early. It's a little early for thyroid cancer. If one looks and figures that there are about 50 million people in the Ukraine and one would apply U.S. statistics on childhood thyroid cancer, there should be about 100 cases a year. There were two cases a year reported before the accident, and our epidemiologists who reviewed

the cancer registry data in general decided that cancer reporting in all the republics that we looked at was substantially underreported from what should have been there. The levels are substantially below what was reported in Poland and Czechoslovakia, for example. So much of the data is coming from a base that was unsatisfactory in terms of not reporting what probably was there.

Now, is there an increase? There could be, but the data doesn't show a definite radiation increase, and the data doesn't exclude it, either. So we came away saying that we didn't know whether there was an increase in thyroid cancer or leukemia at this time but that they were issues that we would be concerned about, certainly.

We tried to predict future health effects, and we do think there probably will be an increase in cancers over the next 70 years. If one takes a village of 10,000 people and looks at that and says, what will the general cancer rate be? Well, cancer deaths, at least in the U.S., are about 17 percent, so that would be 1,700 people. We think that might go to 1,750. So 50 people in a village of 10,000 might in fact be expected to develop cancers. Of those, about six of those deaths would probably be from leukemias.

We did find generally poor health in the Soviet Union and poor medical care. We felt that 15 to 20 percent of the adults that we saw should be under the care of a doctor at the time that we saw them. They were sick. It was predominantly hypertension, alcoholism, and other things. Their salt intake is about 12 grams a day compared to two grams in the U.S. They don't have a choice. They don't have refrigerators, so they're going to continue to eat salt and they're going to continue to be hypertensive. On the other hand, they have no access to medicines to treat the hypertension. The needles that we used, the disposable needles, they were trying to save and re-use because they didn't have needles, which, of course, goes against all of our training. But certainly dental hygiene, the need for antibiotics, all are significant issues in all of the areas that we went.

We think there is a definite need for increased education, as has been pointed by the previous speaker, bringing people to this country, teaching them. We do not think it's a good idea to just give them a high-tech piece of equipment, one, without the education; two, without the reagents; and three, without being able to get access to the spare parts.

Currently, there are efforts by the Department of Energy, the Nuclear Regulatory Commission, the State Department, and the National Cancer Institute. The National Cancer Institute I know is working on protocols for studying thyroid cancer and leukemia. I believe one of their major problems at this point is trying to figure out who's in charge and to be able to deal with on a continuing basis. Obviously, if one is spending millions on a project, in setting it up and knowing the project is going to probably go for 20 or 30 years, one would like to have the same people running it from either the Ukrainian or the Byelorussian side, and it's not easy to figure that out at this point.

There is a lot of data available on acute radiation syndrome from the accident, and I think at this point, as near as I can tell, the Department of Energy is interested in following that.

So I think there are some things to be done. I think our project had some benefit in getting attention off things like anemia and directing it to the right areas where future work should be done.

Thank you.

Senator GRAHAM. Thank you, Doctor.

Dr. Werteleckyj, Professor and Chairman of the Department of Medical Genetics at the University of South Alabama.

STATEMENT OF DR. WLADIMIR WERTELECKYJ, PROFESSOR AND CHAIRMAN, DEPARTMENT OF MEDICAL GENETICS, UNIVERSITY OF SOUTH ALABAMA, AND ACTING COORDINATOR, AMERICAN-UKRAINIAN MEDICAL SCIENCES GROUP

Dr. WERTELECKYJ. Thank you. I want to thank the committee for this opportunity to present some views.

I want to point out that one of the consequences of gain in independence was an abrupt loss of medical support that formerly stemmed from Moscow. Another consequence was that Ukraine has virtually no representation in key international bodies, such as the World Health Organization, or including studies, as Dr. Mettler alluded to. Ukraine has no foreign currency reserves, and Ukrainian authorities have officially recognized that they are unable to cope with the general medical crisis, much less with those issues stemming from Chernobyl, and they have called openly for international participation and assistance.

For brevity's sake, I'm not going to allude to myself, but I will point out two things about the importance on the subject and what is the group that was formed trying to contribute some ideas toward possible solutions.

Radioactivity is the best-known example of an agent that induces cancer, gene mutations, chromosome defects, birth defects, mental retardation, and shortens the life span of those exposed. Furthermore, radiation does not cause single victims. It does afflict entire families, communities, populations, and even future generations. Thus, the Chernobyl tragedy cannot be viewed by a few narrow, specialized scientific windows. Such an approach guarantees the dehumanization of a complexity such as the one that occurred in Chernobyl.

I agree, because I am a scientist, that science is essential if we are going to find and propagate the truth. But sciences in medicine must be complemented by clinical wisdom if what we seek is not just publications or scientific contributions but what we seek is amelioration and healing. It is self-evident that science alone will not change perceptions, attitudes, or behaviors in the case of Chernobyl or, as a matter of fact, in any other complex issue. I'm personally deeply concerned that Chernobyl is increasingly perceived as an example of a failure by industrialized nations to help those whose tragedies were not deserved. Some politicians already find in Chernobyl a good example why western democracies need not be emulated. We have debated six years about helping. I firmly believe, therefore, that America will show others the leadership and humanism that justifies our high standing among other nations.

Concerning the American-Ukrainian Medical Sciences Group, which I represent here, I want to say that we got together because

we are medical investigators and clinicians who hold appointments in universities, teaching hospitals, and scientific centers. Among us are members of the National Academy of Sciences, chairmen of academic departments, experts in genetics, radiology, biophysics, pediatrics, obstetrics, and other specialties. Many of us have considerable teaching and administrative experience. Our group has developed linkages with hundreds of U.S. and Ukrainian scientists and physicians which are interested in Chernobyl and in bilateral participation. The point is that we can now state unambiguously that we know firsthand that there is a sufficient number of qualified and interested professionals both in the U.S. and the Ukraine that can sustain long-term comprehensive, coordinated, and independent projects open to public perusal. Secondly, we are also certain that U.S. academies, many foundations, and charitable organizations will join in such efforts.

Now, we have heard here a report from Dr. Mettler about the best-publicized and probably the worst-received study in Ukraine about the Chernobyl disaster. This is the report by the International Advisory Committee. This study has self-admitted limitations as shown in their own report. The report states that the study was not intended to have neither the rigor nor the comprehensiveness of an elaborate long-term research study, that the number of available independent experts and their time were limited. These were volunteers. That the data provided by the USSR was not always adequate nor could it be independently assessed, particularly concerning the radiologic events that occurred during the accident. That numerous hot spots where exceptionally high surface radioactivity occurred have been excluded from investigation. Evidently, the cytogenetic investigations, for reasons that I do not know, have not been released, and indeed these are needed very badly to know what the effects were. There were no reasons given why the most cytogenetic common standards used to report such accidents were not included in the report.

I want to add the following: Chernobyl is without dispute the largest nuclear accident on record. Within one week, 90,000 children were uprooted and evacuated. The International Advisory Committee also reported that an astounding 72 percent of individuals in contaminated areas were willing to relocate and abandon their homes. The percentages of the population who thought that the government should relocate the whole population were even higher. The number of children and unborn exposed to this radiation remains unknown.

In addition, under the deteriorating economic circumstances that have occurred in those territories, we no longer can dispute that there are other major medical problems, particularly diphtheria epidemics which originally were denied by the authorities.

There is also a growing tendency to "ship" Ukrainian children out of Ukraine, and we heard that 3,000 went to Cuba, which faces difficulties to feed its own population and has limited resources for Chernobyl victims. A growing number of Ukrainians feel that such trends do not address the fundamental problems but actually increase perceptions of inequity.

I will skip other points but at least make two or three more. I think it will become unacceptable to sustain major nuclear safety

projects in Ukraine without a parallel and equally credible effort in investment in people. We cannot depreciate people because the scientific data is not as good as we wish. If I went to any community in West Florida or South Alabama that has 10,000 individuals and I told them that, well, maybe 50 will have to go, I will find out that people do not understand relative risks. They understand absolute risks. They understand what 50 is, but they don't understand what is 50 out of 10,000. America cannot afford to be perceived as a technological giant alone. It is our record in human values that gives us our stature among other nations.

The considerable investment that we made in the studies of Hiroshima and Nagasaki, which we also heard about, was one of the best and wisest scientific investments that this country ever made, and if we had to do it again and if we had to pay twice as much, I would like to know which United States citizen or scientist would vote against it. So that it is not an argument whether Chernobyl should or should not be studied. The issue is, can we afford not to?

Money alone, I will tell you right now, will not solve any problems whatsoever. People solve problems. Organizations such as the American–Ukrainian Medical Sciences Group that I represent may facilitate linkages between American and Ukrainian medical scientists. Also, there are many other Ukrainian organizations, both academic and charitable, who have firsthand experience and have established bilateral linkages with Ukraine.

There are hundreds of thousands of American–Ukrainian citizens in this country, and they are immigrants because they could not survive in Ukraine. These people are nurturing these organizations, they have already formed frameworks that can facilitate the flow of assistance through established and experienced networks that can facilitate accountability, and they certainly understand the contrast between those that think in terms of the former communist-dominated areas and those that rejected communism. These organizations are here and they can be used for creative, innovative ways of introducing American technology and know-how rather than using old approaches or templates that often don't work.

I believe that the effectiveness of any aid, particularly in medicine, will depend upon very careful planning. It is self-evident that the contrast between the Soviet system and our system, added to the language barriers, are phenomenal. A key role of a group like ours is to expedite the formation of bilateral planning, bilateral coordination, bilateral supervisory teams, and to provide as many consultants as possible to pave the way. I think that the goals and objectives of a medical aid program should fundamentally investigate, cure, and ameliorate the effects of the Chernobyl disaster as well as to instill public trust in the U.S. medical and scientific institutions. The major goals for assistance can be grouped into two domains: those of immediate medical assistance, and those that require the creation of stable platforms such as an American–Ukrainian Medical Sciences Center or equivalents.

Among the immediate needs, our group endorses the recommendations of the International Advisory Committee wholeheartedly, and we add a few more thoughts. The International Committee recommended that energetic action should be taken to improve the

standard of medical diagnostic and research equipment and the availability of medical supplies. For instance, Ukrainian kids need diphtheria vaccines. The American Academy of Pediatrics recognizes this need. Badly needed are medical programs for children based on their potential risk for cancer. Nobody disputes this need. Assessment of genetic effects and chromosomal abnormalities. I see no data except from Germany or other faraway lands. That needs to be done.

Programs to alleviate psychological effects. I remind anyone in this room that when we had the Buffalo Creek disaster in West Virginia, 125 people died when the dam broke, but American psychiatry now alludes to "Buffalo Creek syndrome". Eighty percent of the survivors had serious psychological problems. We also think that we should develop programs with emphasis on high-risk populations, just as the International Advisory Committee recommends. We must focus on those that had the most exposure unwillingly. Those are called euphemistically "hot spots". It is not rational to accept the fact that people can walk around them, as stated a few minutes ago.

We think that there is a deep need for public information. I think the public is fully aware of the potential effects of radiation, but they need to know facts and they need to trust those that dispense these facts. For instance, after Chernobyl, there has been an increased rate of abortions in lands as far as Italy, Denmark, and Sweden. We have no idea about the degree of such effects of Chernobyl on the reproductive patterns in Ukraine, direct or indirect. I also think we need to provide incentives for joint ventures to develop a pharmaceutical infrastructure. I think that drugs can be initially packaged, vaccines can be initially partially manufactured by creative tripartite or even more complex arrangements. These are urgent matters.

We need to provide incentives for businesses to engage in joint ventures in medical technology, and the engineering is there, but it's focused on the defense industry. We need to particularly single out how technology can provide Ukraine with a better food chain.

Specifically, I would like to only call attention to the issues related to thyroid cancer. We heard before that studies may have been undertaken too soon. Then we should not talk. The International Advisory Committee stated that the available data reviewed do not provide an adequate basis for determining whether there has been an increase in leukemia and thyroid cancer as a consequence of the accident. Let's face the fact that there may have been 800,000 children exposed. Investigations by Brookhaven National Laboratory and others in the U.S. have shown that when you find thyroid symptoms in radiation-exposed kids in Utah or Arizona, only 3 percent knew that they had thyroid disease. So unless somebody goes and studies those Ukrainian kids, nobody will know, because the symptoms will not be apparent. And the most likely victim which incorporates radioactive iodine is the unborn. Purely epidemiologic studies of risks and outcomes are humanistically unacceptable. Investigations have to include medical monitoring, health care, and prevention. Hundreds of thousands of Ukrainian children need follow up.

The magnitude of the problem is illustrated by the fact that the highest level of radioactive iodine ever recorded in a single day in the United States was as a consequence of Chernobyl on May 11th in Vermont. In Scotland and in France, by May 10th the thyroids of calf and cattle were removed from the market. I suggest that human thyroids should raise the same concerns as animal thyroids.

About the psychological effects, I think that they are to be expected and they must be handled soon, for I think, from what I understand, the situation is deteriorating. People that deteriorate psychologically deteriorate rationally, and solutions become more expensive and difficult.

Now, I think we have been belaboring as to how to make aid most effective, and whether aid will favor medium or long-term objectives will depend on the kind of support found. I firmly believe that the creation of an American-Ukrainian Medical Sciences Center would provide a long-term platform for rapid and effective introduction of technology along with clinical know-how. The process can be initiated promptly by the establishment of centers of excellence, which will function as independent, nongovernmental medical and research facilities under joint U.S.-Ukrainian control and subject to U.S. standards. Each center will promote, facilitate, and provide a stable home base for U.S. scientists in Ukraine, and the equivalent could be developed in the U.S.. The centers would be eventually amalgamated into an American-Ukrainian Medical Sciences Center, and an interim step would be an amalgamation into an American-Ukrainian Children's Center.

The urgency of this medical crisis in Ukraine calls for an immediate development of at least two centers of excellence, an American-Ukrainian Cancer/Leukemia Center, because of the thyroid leukemia threat, and an American-Ukrainian Teratogenetic Center, because people are afraid to have children.

As a major component of a proposed American-Ukrainian Medical Sciences Center, there should be also an information data repository and public information program, which would include and promote epidemiology, coordination, education, and so forth. Much of the aid reaching Ukraine thus far, and it's considerable, has come from American-Ukrainians and local business communities. The plan to develop centers of excellence aims to provide incentives for participation by businesses and nongovernmental organizations.

These centers will inherently become showcases of American technology and know-how. An American Children's Hospital and later an American Medical Sciences Center will provide high-quality medical care subject to U.S. standards and be open to patients beyond Ukraine. An impact of such medical facility in eastern Europe is likely to be substantial. We ask that this committee endorse such plans and seek funding to propel implementations. We have indications that the Ukrainian authorities are prepared to either delegate hospitals and laboratory facilities or otherwise welcome construction of new ones.

To conclude, I believe that substantial aid to Ukraine is warranted on humanitarian, scientific, as well as geopolitical grounds. The U.S. has heavily invested in the investigations of Hiroshima-Nagasaki. A similar investment is needed to study and ameliorate Cher-

nobyl. An American-Ukrainian Medical Center is an effective way to provide for the integration of complex long-term research, medical care, and public information projects. It is also a highly visible contribution that will demonstrate the creativity of the U.S. and its role in a highly sensitive area.

Furthermore, a helping hand from America is the most effective way to promote our own democracy. The fate of the emerging democracy in Ukraine will have profound implications, and the aid provided thus far has been primarily nongovernmental. The American-Ukrainian community has created linkages and now probably will be seeking from our Government leadership and support.

Thank you.

Senator GRAHAM. Thank you very much, Doctor.

Mr. Edward Purvis, Senior Engineer of Los Alamos Technical Associates.

STATEMENT OF EDWARD E. PURVIS, III, SENIOR ENGINEER, LOS ALAMOS TECHNICAL ASSOCIATES, INC.

Mr. PURVIS. Mr. Chairman, thank you.

I was assisted in the preparation of this testimony by Dr. Marvin Goldman, who is the leader on the U.S. side of the joint working group on the health effects of Chernobyl. His statement is included in the submittal for the record. I will allude to information from it, but I will concentrate on discussing the technical details about the physical situation at Chernobyl, in particular the sarcophagus in the nearby area. I appreciate the opportunity to review this.

To understand the current situation, it would help to best review exactly what happened. The accident resulted from some design flaws and some major operational problems. These led to a reactivity excursion, which was a very large, rapid increase in power. The actual part that really led to the results that you see lasted about two-tenths of a second, and the power level went up to where it generated in that burst about 32 gigajoules of energy. That's an awful lot. It resulted in a very small fraction of the fuel in the reactor going up to a temperature of about 13,000 degrees Fahrenheit before the expansion of this now gaseous mass could disrupt it. That was the major part of the damaging energy release.

What you now have is gaseous fuel putting a shock wave on the fuel fragments, which took the graphite and the fuel—some of it was very fine particles, some of it was larger fragments, some of it was intact—and threw it onto the roof and into the yard. A lot of it was left in what is now the sarcophagus. It was very, very hot. The gases condensed, formed aerosols, and so forth. The hot fuel in contact with the graphite caused burning, which resulted in radioisotopes being released and going very high up into the atmosphere, where they were dispersed over a very large area.

The exact amount of some isotopes, like radioactive iodine, that were released and that were dispersed to the environment and where it went will never be known. The reason is radioactive iodine has a very short half-life, and there was no instrumentation available to detect this. That data is lost. This is very important with respect to what they were referring to on the thyroid gland and the children in particular. Other isotopes, such as cesium, can

be and have been mapped fairly well. Some isotopes, such as strontium and plutonium, require soil samples. To really get a good map and determine where all the hot spots are, you have to take a lot of soil samples. These are very expensive. Then you'd have the data to really know where the hot spots are. With some of the data taken, you don't have the exact location of where the soil samples came from, and there were problems on the measurements.

So there's a lot that still needs to be known when you get away from the sarcophagus. But there is some pretty good information on what the situation is in and near the sarcophagus, and from now on I'll try and concentrate on that.

As I said, a small percentage of the fuel was vaporized and dispersed over a very large area. Some of the fuel assemblies were blown into the yard. Some of the fuel was on the roof. There are video pictures which I believe you've seen that show people taking the graphite fuel and throwing it off the roof down into the inside of the building. There's a picture that I provided you showing one of the workmen up on the roof shoveling up the graphite that was laying there. The fuel elements that were out in the yard were basically scooped up. Some of them were put in the sarcophagus. The dirt and all the other stuff was taken to pits within 10 miles of the sarcophagus and buried.

So you have those fission products that were put there and the fuel which is sitting in a pit. This pit is not very far above the water table. In fact, because of how close the water table is to the surface of the ground, many of these burial pits may be below the water table. When they finished the cleanup activity, a lot of the equipment and vehicles and things that were used got very heavily contaminated in the cleanup operation were also put in these burial pits, and I would like to emphasize that this was done under conditions where they really did not make sure that there was good containment of this stuff. They were trying to clear the area so they could work on the larger problem, and as such, they created some significant residual problems.

At the time of the accident, there were about 420,000 pounds of fuel in the reactor. There have been some fairly good measurements made and some fairly good estimates made. It is now estimated with pretty good confidence that between 12,600 and 16,800 pounds of this fuel was released from the volume which is now covered by the sarcophagus. That's the fuel that was blown out in the yard and that was the fine fragments that was distributed over the area. That's the fuel that's been gathered and either returned to the sarcophagus or buried into the burial pits.

There were 19,000 tons of material that was dropped onto the reactor in the first month or month and a half after the accident. This was done in an attempt to—successful attempt, I might add—prevent the fire from further dispersing and releasing radioactive material and to do something to put some type of containment on it. There was a tunnel over 400 feet long that was dug up under there to allow them to put liquid nitrogen to try and bring the temperatures down.

The combination of all these events—they basically buried the core that was releasing the radioactivity under a big pile of dirt and other stuff, which managed to slow but not halt the releases.

The temperatures, however, were so high that what happened was the sand and other stuff like limestone, that was in the material dropped on the reactor melted and formed a lava-like material. This lava-like material contains the bulk of the fuel that remained in what is now covered by the sarcophagus.

The RBMK reactor had a pressure relief system. In case a pressure tube breaks, there would be a pressure pulse in the core, and to prevent an overpressure situation, there were pipes that took this overpressure into suppression pools under the reactor, where it bubbled through water to attend to the pressure. The molten fuel suspended in this lava-like mass ran through these pipes. The temperature of the lava was less than the melting point of the pipes. So it ran through these pipes and coated the bottom of the suppression pools. It formed a big mass under the reactor.

There was a 6.6-foot thick concrete floor under the reactor core. After the accident, in some places, measurements show that there are eight to 20 inches of good concrete left, and the area above that is remaining of the now solidified, molten core mass. The floor of the suppression pools are coated with this lava-like substance. A lot of it's still in the pipes. There are a couple of pictures I provided you showing what looks like spaghetti coming out of one of the valves, which is the molten material.

Now, this molten mass immediately after the accident was putting out radiation dose rates on the order of 20,000 r/hour. The so-called elephant's foot, which I provided you a picture of, is probably down to about 2,000 r/hour now. There are certain hot spots there which contain lots of fuel that are still on the order of 2,000 or 3,000 r/hour. There are other areas there where it's down quite low, one r/hour or less. It depends on how much fuel dissolved in that particular mass of lava.

Above the core on what used to be the operating floor of the reactor, you have the fuel and graphite that was thrown in from the roof, you have the fuel and graphite that was left laying on the floor from the explosion, you have the fragments which settled back in there. The vaporized fuel condensed and formed aerosols and fine particulate matter which is in there.

Now, with that situation, after the accident they took actions to prevent and to mitigate the releases of radionuclides. They very rapidly designed the sarcophagus, which you've seen pictures of. This was not what you would call a sophisticated design project taking lots and lots of time. It was something that was worked out really quick that could be done really quick. They scooped up the dirt around there so they could get the radiation levels down so that people could work. They made prefabricated frameworks near the site which they moved into the site and pumped concrete into.

In the process of doing this, one of the things they did not do was compact the dirt under the sarcophagus so that it could hold this large mass of concrete and structure that they had put on top of it. The work was done such that the normal quality control that would be done to a massive concrete structure like that could not be done, so you're not really assured that the concrete will be good, strong concrete like you would find in a normal construction project.

So the situation now is you have a very hastily built structure which was built to respond to an emergency situation that covers a region which contains lava either as a glassy mass, as a kind of friable pumice, or as fine particulate dust, and that's what's in the sarcophagus. The sarcophagus is not a confinement building. If you stretch a point, it's a containment building, but it's got really big holes in it.

Now, as a result of these measures, the release rates from the sarcophagus area now are normally very, very low. But some of the radionuclides inside the sarcophagus are in a form that can be released from the sarcophagus under a number of conditions. It's not hermetically sealed. I reiterate that. Examples of release mechanisms are there was a big cover that went over the reactor which weighs over 2,000 tons, which was thrown over and is sitting there cocked on its side.

Nobody knows how well supported that cover is, is it going to fall down. You just don't know. It might be wedged in there so solid that there's no way you can get it to fall. It might be in there so that it won't take too much to knock it over. If that big cover comes down, it's going to kick up a pretty big stack of dust, which is going to make a significant release.

The sarcophagus is open so that birds, insects, animals come in and out, live in there, and this provides a mechanism for dispersing material into the biosphere. Under some weather conditions, the release rates go up just because of atmospheric conditions. This just varies with the weather.

And as you mentioned in your opening remark, the sarcophagus is crumbling. It's rusting away. The ground is settling unevenly. The concrete is weak, and it's crumbling. I don't know whether it will last five years or 10 years, but it's deteriorating, and as time goes on, the holes get bigger and its ability to contain radionuclides gets less.

The burial pits that I mentioned in the areas around there are also a problem, because the material in these pits can diffuse into the water table. If you look at the map, you can see where the water goes. There are hot spots around the region. Some of them are defined, but they're not all well defined. You don't have a nice map that lets you know exactly what areas you should walk around. These, I think, come from folk knowledge, and I'm not quite sure how good the folk knowledge is.

The natural processes of decay have reduced the level of radiation to about 15 to 20 percent of what it was originally. Another way of putting it, though, is you had an awful lot released initially, and 20 percent of an awful lot is still an awful lot. So there are still problems.

The problem has not been resolved. It's being controlled. Risks have been reduced by various actions that have been taken, but all the actions that could be taken have not yet been taken. There are a lot of uncertainties on just what the situation is.

Cleaning up the situation there can reduce future exposures and further risk. You don't have to wait 100 years, or however long it takes, for the radiation to decay from natural processes for the risk to go away. Yes, it has gone down by about 80 percent due to natural decay, but that goes down rapidly initially, and you're now

down on the kind of horizontal part of the core, not the near vertical part. So further reductions by natural processes will be pretty slow.

The dispersal into the biosphere will continue as migration and so forth goes unless something is done. This has been given a very careful look. The actions that need to be done have been identified.

There is a work breakdown structure. That will be discussed later on. You all have been provided a copy of what are the actions and what can be done. A lot of this, the vast bulk of it, will done with Ukrainian resources. But there are some things that will require resources from places other than the Ukraine. At the front end of the process, to get things started, a need is the hard currency that's required to get things going. The work—I'll stick to the sarcophagus, but these comments apply to pretty much everywhere else. The work must be done in kind of a logical sequence. First things first.

For example, if you look at the work that has been done in the sarcophagus to date, a lot of people went in there under controlled conditions to get this information that we have. But when you go to the next step of trying to get that mass of radioactive material out and contained, people can't do that. A lot of that work is going to have to be done by remote or robotic equipment. They don't have that equipment. They don't have the technology to get that situation under control where people can carry out the rest of the job.

So what you've got to do is, first, you have to stabilize the situation so that the dust and radioactive material isn't migrating and the situation's better under control. Then you need to collect and encapsulate, place under control, the material that's in the sarcophagus. This might be something simple like chipping it up, putting it in barrels, and putting it in a safe, secure condition. And then third, you have to confine, decontaminate, and clean up the remaining area. That might be done by more concrete chipping, or it might be done by something simple like pumping concrete in. There's a variety of actions that could be used.

At the end, there are a spectrum of options, and there are two major ones, at each extreme, that I'll just give to scope the problem. One option I'll call green fielding. When you finish, there's a nice green field there with a fence around it, and that's what you see. At the other extreme, you have a big structure over it, in which a lot of the stuff is still there but is contained, and you now have a permanent containment structure as opposed to the temporary confinement structure.

There are other examples that could be used as to where the U.S. technology can apply to this, and you all have been provided that information. The identification of what needs to be done I think has pretty well been identified. I think the technology is available and we know what to do, and the quicker it's done, the less the residual risks are. It's pretty much that simple.

Thank you very much.

Senator GRAHAM. Thank you, Mr. Purvis.

Dr. Murray Feshbach, Research Professor of Demography, Georgetown University.

STATEMENT OF DR. MURRAY FESHBACH, RESEARCH PROFESSOR OF DEMOGRAPHY, DEPARTMENT OF DEMOGRAPHY, GEORGETOWN UNIVERSITY, WASHINGTON, D.C.

Dr. FESHBACH. Thank you, Senator. Thank, of course, the committee and the staff for inviting me to testify on this important issue.

My viewpoint is that the situation is much worse than hitherto deemed to be the case and that new evidence confirms this rising problem.

First, I am not opposed to nuclear power per se. I am opposed to the way the Soviets did, and the newly independent states continue to operate their facilities. It is a very different ball game than, say, in France or Belgium or Canada or the United States, though problems there, of course, exist. It is also a question of whether the remaining RBMK-type reactors, VVERs, are potential accidents waiting to happen. I believe they are, and I believe that we need to do quite a bit. If nothing else, at least get them containment structures to reduce it.

But it is not just Chernobyl-type reactors, civilian reactors, of course. It is all the radiation emanating from the northern seas where instead of 50 million curies, as released by Chernobyl, there may be up to 3,500 million curies. Chelybinsk, with 1,200 million curies, nuclear reactors all over the place, 600 radioactive sites in Moscow City alone, two in Gorky Park—it is not very healthful to the population, let alone to the potential hazard for those in Scandinavia, let's say, who are very close to the northern seas area, but also, I think, the United States, Canada, Japan, et cetera.

Now, in addition, the question is, how far spread is the impact of Chernobyl? The original report, when finally it was released, told us about five oblasts so-called, or roughly equivalent to our States: two in the Ukraine, two in Byelorussia, and one in Russia. Well, the first four hold, but instead of the one in Russia, the number is 15. That is the current figure where there is at least an average of one curie of radioactivity of cesium-137 per square kilometer. So the problem is much larger than just the terrible problem that we knew it was before, and I will not read the list because it is in my written testimony and go on beyond that.

In addition, we know that they have not yet measured what the impact of Chernobyl has been in Siberia and the Far East. That is beyond the Urals, if you wish. And that they are aware of, but they are just beginning to measure it.

The other issue is about this renowned International Atomic Energy Agency report, of which we heard a lot today. I believe it is wrong for at least four reasons, some of which were addressed, not because of the brilliant people—the physicists, epidemiologists, medical people, whatever—they brought in, but for other reasons. First, I think it was, of course, conducted much too early, and this was also mentioned before by the other witness, by Dr. Mettler. The latest data they could have had was for 1989 and more likely for 1988, only several years after the accident. Much of the peak experience we had from Hiroshima and Nagasaki is six, seven, eight, nine years later when you get large numbers of leukemia and thyroid cancer showing from low doses of radiation, let alone

those who got, shall we say, blasted immediately by the radiation and their activities. And those data are beginning to show up now, and I will tell you about them in a few minutes.

Every Soviet analyst, epidemiologist, government advisor, or green party member that I asked whether the IAEA people ask for the data from the Third Administration of the Ministry of Health in the USSR, not a single one told me that they did. Maybe they did not know about it. Many Sovietologists do not know—whatever we are called these days—that there is such a thing as the Third Administration. We all know about the Fourth Administration. The Fourth Administration is where the elite gets their medical treatment and where there are good facilities if you survive the surgery, because everybody is politically cleared, then the service is very good. The question is surviving the surgery. But that is the Fourth Administration. That is what the former Minister of Health Chazov was in charge of.

The Third Administration, however, is where the secret data are for all nuclear, biological, and chemical accidents, and my understanding is that they have the data for 500,000 people. These are the classified data and not the public data to which they were told to lie about. There are instructions which I have cited in my book and elsewhere which are the data what they are told they will not classify as radiation-related.

Now, to say the least that they are very bad diagnosticians, that they have a lack of equipment, I hae written about this many times and it does not bear repeating. I absolutely agree with that evaluation that we need to teach them proper epidemiology, proper diagnostics, give them the proper equipment, et cetera, so they really could know what is going on. But at the same time, there are many people within the military or classified establishments who do know, and that is certainly not Academician Il'in, who has lied to a tremendous extent. There are many Soviets I know, or ex-Soviets, Russians, whatever, who you mention his name and are not very happy about it.

Then again, I think the sample was too small in putting only the 100,000 persons still resident in the region and not those who went out to Estonia, Central Asia, the 5,000 liquidators who worked in Latvia, the 12,000 in Uzbekistan. They were not incorporated, and I think they deserve to have been included, even if it was difficult to get hold of the data. That is what you were asked to do, and you do it. I think that the testimony that was provided to them was omitted from consideration. I know of an individual who showed them materials for every single birth in Zhitomir, Skaya Oblast, one of the areas that was very badly affected by the accident, and in every single sub-unit within that oblast, what the different kinds of congenital anomalies and the multipliers between 1985 and 1990 at 2.5 to seven times more. He tells me that these data were totally ignored in the final writeup. Now, maybe that is true, maybe it is not true, but it certainly is believed by all of the people that I spoke to and a very wide range of people in the medical establishment and the environmental establishment.

Now, because there is very short time, let me just run through quickly the recent evidence, and it is very recent. This includes only data published this year for what has happened over the past

couple of years, perhaps three years to four years after the IAEA report could possibly have covered for the time they went and when they were asked to do it. And again, it is not the individuals. I think it was other kinds of limits.

In late March of 1992, the Ukrainian Parliamentary Commission on Chernobyl said that 37 Ukrainians and Byelorussians were diagnosed with thyroid cancer in 1991 and 1992 up to that date. Before this point in time, only one or two cases per year. In mid-April 1992 the Byelorussian Parliament said 1,700 cases of thyroid cancer were recorded in the republic or country, with 35 children afflicted. For 20 years up to 1986, only five adults and no children. So double the number. Triple the number. It makes no difference. Even if they were bad diagnosticians and you even halve the 1,700, it still leaves an enormous gap between the numbers that could have been the case then and which are reported now.

Since the beginning of this year—that is, up until June of this year—an additional 299 persons were diagnosed with thyroid cancer, including 52 children, in these first several months. That is, again, additional to the 1,700 count. But how many were not officially recorded? How many have not been properly diagnosed or maybe perhaps overdiagnosed in the sense that something is exaggerated? So again, as I said, discount the numbers even by 50 percent in comparison to the period prior to 1986, it is just an enormous difference.

The Byelorussian Congress on Chernobyl in April of this year, the speaker indicated that almost 200,000 children in Byelorussia have enlarged thyroids. Now, how many will progress into thyroid cancer is not known, but certainly some 5 or 10 percent. If that is the number, another 10,000 to 20,000 additional cases. In Ukraine, thyroid cancers increased by 17 times in the period of 1986 to 1991, from a rate of .13 cases per 100,000 to its present level of 2.2 per hundred thousand. The Ukrainian Minister for Cleanup of Chernobyl has stated that this year he believes that there are 6,000 to 8,000 excess deaths in Ukraine from Chernobyl. Not 31, not 150, 250, or 5,000 over 70 years, but 6,000 to 8,000 currently. And this does not include Byelorussia or Estonia, Russia, Latvia, and other areas.

The Ukrainian Minister of Environment, Yuri Shcherbak, has said that potential mortal doses of radiation have been suffered by 365,000 persons. Mr. Shcherbak is not a man who tends to exaggerate per se. He is not only a physician, but he is also, as I said, the Minister of Environment. And he said by this time, 7,000 persons who participated in the emergency work have died, not 32, 150, whatever.

Well, even if these figures are double or triple or whatever that number is, it is many more than the numbers recorded previously, and I think it is probably an understatement rather than an overstatement. Of course there is radiophobia. Why shouldn't there have been? I was in Belgium serving in the Office of the Secretary General, Lord Carrington, as the Sovietologist-in-residence at the time, and Belgium was affected by the plume as well, just as much as many other areas were. I can well empathize with the fact that people can be phobic about radiation, but, of course, the question is, then, what is objective evidence, not just that?

Well, in the May 1992 issue of the Health Journal of Byelorussia, they give data comparing three contaminated regions with five control regions, those which were relatively clean, classified by number of curies per square kilometer, and the numbers there are many multiples higher—50 percent higher, or 25 percent higher, or 4 times higher, depending upon a whole long list of illnesses as diagnosed there in comparison between the regions at the present time. So I think we need to know much more, but again, I think the problem is much more serious than has been measured hitherto.

Thank you, Senator.

Senator GRAHAM. Thank you, Doctor.

As I indicated in my opening statement, this hearing is largely at the suggestion of Senator Lieberman, who is with us.

Senator Lieberman, would you have a statement to make before we proceed to questions?

OPENING STATEMENT OF HON. JOSEPH I. LIEBERMAN, U.S. SENATOR FROM THE STATE OF CONNECTICUT

Senator LIEBERMAN. Just very briefly, Mr. Chairman, to thank you for your interest in this subject. We were all startled, traumatized when this tragedy occurred. There's a natural way in which our attention moves on to what seemed to be more current contemporary problems, and it's important that we not do that, we not turn our backs on what happened at Chernobyl either from the point of view of learning technologically, if I can put it that way, what happened so that hopefully we can prevent it from happening elsewhere, first and foremost, within the former Soviet Union, and secondly, in trying to evaluate the tragic human consequences and what we can do about them.

My own attention has been fixed by my friends in the Children of Chernobyl group, which Dr. Matkiwsky leads, and I see Alex Cozma from Connecticut, a friend and constituent who's here, and it was really their coming to me that brought me back to this event and its aftermath, and I, at the outset, wanted to thank you for responding to that interest and for assembling this extraordinary group of witnesses.

Senator GRAHAM. Thank you very much, Senator.

This panel has been in fairly sharp disagreement with the methodology and effectiveness of the International Chernobyl Project efforts to assess the health effects. I wonder if, without debating the specifics, we could talk about the methodology and what we have learned from this process in terms of both further efforts to understand the Chernobyl disaster and to be prepared in the event that a similar situation necessitated an examination of its consequences.

Dr. Mettler, I wonder if you could give us your assessment of what you think we've learned about the process of evaluating the health impacts of a Chernobyl-type incident.

Dr. METTLER. Well, I think there are certainly a lot of lessons to be learned. One of them is that one would like to begin the evaluation at the time of the accident, and obviously, that evaluation here wasn't begun until four and a half years later, at least by external groups. Prior to that time, the Soviets themselves had diffi-

culty because much of the data was kept secret between one village and the next, and even people who were generating data weren't sure where it was going or what was happening to it. So I think a lot of valuable information was lost.

There certainly is a residual major problem, particularly with the thyroid, and that is that the thyroid damage will predominantly be due to radioactive iodine, which has a very short half-life—about eight days—so that within several months after the accident, it was virtually impossible to make any measurements to discover where the iodine had gone. The international group basically came away and said, "Well, we know where the cesium is"—that's what that map is—"but where the iodine went is another story." And there were hundreds of thousands of measurements made of iodine with completely different protocols, under completely different circumstances, and the reliability of those is subject to significant doubt.

So we don't know a lot because we weren't there early, and in fact, the magnitude of this accident, I think, is an important problem, and I think the distribution, as you can see from that map, is a significant problem. The Soviets initially decided to evacuate the 30-kilometer zone, and if you get actually slightly more detailed maps than the one that's up there, there are some places inside the 30-kilometer zone where there's very little radioactivity. So in fact, one could be living, at least some spots, inside the 30-kilometer zone and be getting less radiation than at some places 300 kilometers from the accident.

Now, that, in the accident management scenario—and it's true for the U.S. We have a 10-mile evacuation zone around our reactors. Well, what this shows you is that if you have this type of accident, it could go a long way and drop someplace where you're totally unprepared, and in fact, you may end up evacuating people out of a place that doesn't have much radioactivity and into a place that does. And you're certainly subject to the vagaries of the weather. We had that difficulty at TMI. I think at least on one day at TMI, the wind changed on us 270 degrees. So evacuation is a real problem.

Certainly the magnitude of this accident is a major problem, and I don't think any country would have had the resources to deal with this in what anybody would have liked to think of as an optimum way. When one looks at distribution of potassium iodide to block thyroid gland, less than 20 percent of the people in the contaminated areas actually took any. But I'm not sure that we would have had the resources to do it, either. We certainly don't have the resources to handle measurements that quickly on that kind of a geographical scale and in that kind of inhomogeneous fallout. So I think it became quite clear that when you have this sort of a problem, no country, including the U.S., can handle it alone, and an international effort has to be done.

I think it's clear that the base line of health effects data before the accident is extremely poor, and it wouldn't be too good in this country, either. We don't go around doing hemoglobins on perfectly normal children, or at least the ones that aren't complaining. And if we went to a city or someplace in the United States and started randomly doing blood testing, we'd find all sorts of things that

people just haven't complained about. So the base of data is an issue.

I think it's extremely unfortunate that this reactor happens to sit on the border of three republics. What we saw when we were there was not sharing of data between republics. They all were doing things with different methodologies, so that a study performed in the Ukraine was being done with methodology that was different in Byelorussia and different in Russia, so you couldn't easily compare results. So there is a need for standardized ways of doing things so you can at least get comparable results.

The fact that this thing is sitting on three administrative boundaries is still causing trouble. I think you've heard a suggestion today for a Ukrainian-American Medical Center. I can assure you the Byelorussians would want one as well, and in fact, there are more exposed people in Byelorussia probably.

I think we have to get away sort of from the nationalistic aspects of it and deal with the accident itself. That is proving to be quite difficult. I know that the current efforts by the United States are hampered by having to try and form one agreement with people in Minsk and a different agreement under different circumstances to study the thyroid in Kiev and a different agreement with the Russians.

It is clear at this point, and I agree with the speaker and we pointed this out ourselves, that acute effects in the population that we looked at were not likely from the doses that we had expected. Acute effects are clearly in these other populations. Studying them is going to be a huge, major task and in fact probably an impossible task, and that's one of the reasons in our recommendations that we said let's find the people with the biggest doses and the ones at most risk and study them. That goes against much of the philosophy of this region where everybody should have everything equally, and it's a difficult problem when you say, "I want to study this group," and they say, "No, no, no, you have to study all 300,000 people," and you just don't have the resources or the expertise to do that. So there's a problem between studying the people who got the higher doses and this philosophy of everybody ought to have the same thing, and I don't know how to solve that problem.

It is clear, as has been pointed out I think by everybody, that the long-term effects are not generally specific to radiation. They will be hard to sort out. When a child gets leukemia, is it a child who is from a relatively clean area? Is it one who was from a contaminated area? As you can see, when you get an inhomogeneous distribution like that, when you start reporting data by oblast or state, you get a mixture of some 75 percent of the people may not have received much contamination and the other 25 percent might have, and your data is all mixed up. You need to sort the data out by contaminated areas versus noncontaminated as opposed to collecting it by state, if you will.

I think there is a residual major problem at this point, and that is coordination of what is to be done. I think there are a lot of things that need to be done—education, equipment, general medical problems. However, there are bilateral agreements which were in place before the independence of these republics. There were bilateral agreements between the Japanese government and the So-

viets, there were bilateral agreements between the Germans, the French, the U.S., and other countries. What's happened now is that nobody is sure where those bilateral agreements stand.

One of the people I know from the World Health Organization was in one of these villages not so long ago, and there was a van there studying people from Japan, there was a group from Germany with a medical van, and there was a church group from England with a van, and they were all set up on the town square trying to entice people to bring their children to be studied. And, of course, they were using totally different protocols. Nobody had the faintest idea the other one was going to be there.

You know, this sort of disarray is a real problem, and the World Health Organization has set itself up as a method for coordination. Unfortunately they have decided to set up their headquarters in Obinsk, which is outside of Moscow, and that doesn't sit well with either Byelorussia or the Ukraine, and many of the foreign governments are saying, "Well, we'll deal ourselves with the Ukraine as opposed to through the WHO." So at this point, somebody needs to make up their mind about how this is going to be coordinated so the U.S. isn't doing one thing with the Ukraine, a slightly different protocol in Byelorussia, and we find the Japanese have even a different protocol and are doing something else.

So I think there are a lot of lessons to be gotten out of this, clearly, and it's a problem that will go on for many years. Thank you.

Senator GRAHAM. Do any of the other members of the panel wish to comment on what lessons we have learned?

Dr. MATKIWSKY. I'd like to make a few points.

First, I'd like to comment that Dr. Feshbach mentioned a name, the name of Il'in. I happened to be in Kiev in February of 1990 at a round-table discussion of about 100 people. There were scientists from Russia, Ukraine, and other parts of the Soviet Union at that time. He compared the Chernobyl accident to that of Three Mile Island, which I thought it was rather unusual for him to compare that. This same individual then gave testimonies and supplied information to the Politburo at that time and also to the IAEA, and I'm certain that that's who was the person that supplied most of the information. So the lesson that I think that we all learned is that the entire IAEA project was actually abused, unfortunately, by the Soviets for their own purposes because of the misinformation that they supplied. That's very unfortunate, because I think had they not done it, we would have probably had different statistics today.

The other point that I'd like to make is that I have statistics telling us that the myloid leukemia is the leukemia beginning to surface, and that is the type of leukemia that is caused by the radiation. So up to 1990, it was almost at the same level of myloid leukemia as it used to be before; however, now it is beginning to be on the increase. I think that particular type should be looked at very closely in the next 10 to 15 years.

I, 100 percent, support what Dr. Werteleckyj mentioned, and that is the American-Ukrainian center to study the radiation and its aftereffects. I'd also like to point out that our foundation has three hospitals on, of course, a much smaller scale, but we are trying to develop a medical environment which will be used by the foreign

physicians that come in. Because once we ask foreign physicians from the United States or other parts of the world to come in and to conduct a certain type of studies or show certain techniques, when they come to Ukraine hospitals, there's absolutely no facility where they can feel comfortable to do certain procedures that are done in, let's say, the United States. So we are trying to provide them with that particular thing.

One more thing I want to add is that the article in Izvestiya, Mrs. Yaroshin'ska's article, stated that approximately 17,000 people were hospitalized in May alone, just in May of 1986, with acute radiation syndrome, and subsequently, in that particular year there were over 50,000 people hospitalized for the entire year of 1986. So those are the figures that were just recently released.

And I just want to make another point, that the physicians in Ukraine were absolutely forbidden to give any information. I personally was in Ukraine for approximately 14 times since January 1990, and I can tell you that I had a very difficult time getting any type of information of the statistics and so forth. But since the coup of 1991, that's when we started to get all kinds of information from Moscow and from other parts of Ukraine as well, and I think unfortunately that the IAEA was reporting that before the coup. Had it been after the coup, I'm sure that their information would be different.

Senator GRAHAM. Senator Lieberman.

Senator LIEBERMAN. I don't want to dwell too much on the difference in the response to what happened, because there's a baseline agreement here that something terrible happened, and I presume there's an agreement that we ought to focus on the high-risk populations and try to improve the medical infrastructure.

But I do want to ask you, Dr. Mettler, if you can respond, because there's such a dramatically different reaction to the IAEA report, and basically we're being told that the report is a serious understatement of the problem and is seriously flawed. No reflection on you personally, as people have said. I think the main culprit that we're being pointed to is the former Soviets, who did not share data with you accurately. I suppose I should comment parenthetically that it's ironic how the heavy hand of the state, even after the state has theoretically expired, goes on in terms of what we came to understand as classic Soviet coverup. But how do you respond to these charges about the inaccuracy of your report?

Dr. METTLER. Well, I think, of course, we were concerned about—let me just say that there are two classes of effects that one can study. Those are the things, let's just say, which are very common. There were claims in the press that 30 percent of the children had anemia, that goiter had gone from 30 percent to 70 percent, and a number of claims like that. Now, I think you could appreciate that if you had something in a population that existed 30 percent and radiation took it to 70 percent, statistically you could tell that quite quickly if you looked at 100 people. If you examined it and suddenly found 70 out of 100 with this, you would say, okay, that's clear that has happened.

So that in examining the thousand-plus people that we did very carefully and choosing them very carefully, we are able to exclude with 99 percent statistical certainty many things. Like, did goiter

increase? The answer is not significantly. Did anemia increase? The answer is no. Are the children all stunted? The answer is no. So that the study is very clear, and I don't think you've ever heard anybody talk about those issues.

The issues that remain are the ones which in fact are quite rare conditions. Obviously if something occurred, say, one in 10,000 in the population and I looked at 10,000 people, by chance I might not see any of those cases, or I might see two of them. And if you're looking for something in the range of one in 10,000 occurrence, you now need to study maybe 100,000 or a million people to see whether there's really an increase and be sure of it. To do that, to look for leukemia, to look for thyroid cancers, especially at these dose levels, is a study that's going to take 30 years and is going to involve thousands and thousands and thousands of people. So that the IAEA study never went there to look itself at how many cases of thyroid cancer are there.

The one thing we could do is to look at the existing Soviet data and go from Moscow to the different institutes and see if we were getting the same numbers and go to the institutes that they were deriving them from, and in fact, the numbers that we got from the Ministry of Health in Moscow, we were able to track that data, for example, back to Minsk, where it was put together, and back to the original people who put it together. So that if there was a coverup at least in the cancer statistics data and in the other health data, it was one that began at the grassroots level in many of the republics and went all the way up.

Now, the other thing that was clear to us was that the data we saw was abysmal. I can take the data out and show you—just pick any chart you want, meningitis, cancer statistics, anything—and if you look at a given village, you'll see that in one year they may be reporting, let's say, 50 cases of something, the next year it's two, the next year it's 70, the next year it's one, the next year it's 80, and you say, "Wait a minute. Meningitis doesn't know that the year changed. What is going on here?" It's clear that doctors were coming out from, say, Minsk, visiting that town, making a huge number of diagnoses, and then not coming back for two years.

So the data is awful, and what we came away saying was the data is bad. First of all, we were able to track the numbers. Second of all, if we were going to cover up and manufacture data, we certainly would have manufactured better data than what we were shown. And we came away saying that we don't know if there's an increase, that the data is jumping all over the place, and that we can't do much with that. We can't exclude an increase, and it doesn't prove it's there.

Senator LIEBERMAN. Is there any effort now to try to—I'm thinking about a couple of the statements that Dr. Feshbach made—to update the IAEA study with fresher data?

Dr. METTLER. There is no comparable study on the books anywhere that I know of at this point, and in fact, I think there are some pieces beginning to be put in place. For example, I think there have been people from the Ukraine and from Byelorussia who have gone now to the International Research Center for Cancer in Lyon, France, to learn how the rest of the world puts

tumor registries together. There are people coming to the United States. This is a process that is going to go on for a long time.

Our project, as I say, looked at anemia. I don't think there's any reason to go back and look at anemia again. That's clear. One needs to focus now down on the issues of leukemia and thyroid cancer and spend the money on issues that in fact make sense where we were not able to deal with issues. One of the things he pointed out was cytogenetics. We found some semi-unusual things both in clean and controlled villages, and we said, "Look, this is unusual, and it needs further study." So I think one needs to progress and not go back and repeat everything we did.

Senator LIEBERMAN. But although there is some disagreement between you and most of the rest of the panel on the report, I take it that you would agree that there ought to be continuing monitoring of the high-risk groups and efforts to improve the medical infrastructure?

Dr. METTLER. Sure. This was in our recommendations. Absolutely, yes. And particularly with regard to leukemia and thyroid, which is in fact now what most people are focusing on, and I think that's reasonable.

Senator LIEBERMAN. Dr. Matkiwsky, Dr. Werteleckyj and you mentioned a series of steps—I could call them humanitarian medical—that we might take. What's your counsel to Senator Graham and me about what we as two concerned U.S. Senators should put as their priorities here? Acknowledging obviously the limited resources, but nonetheless, the severity of the problem calls for some reaction.

Dr. MATKIWSKY. I would like to just speak to the more medical problems rather than scientific problems or concerns. Primarily we are interested in obviously the immediate help in situations, such desperate need for antibiotics and medications in general, but also to preserve the very young children, especially in the cardiac defects, which appears to be much larger than it was before, and you have 8,000 or 9,000 small infants dying every year from cardiac defects whereas in the United States or other western world you can save 90 percent of these by surgery. The Ukraine does not have such facility to take care of that, especially now when you have a negative birth and death ratio.

Another area is in neonatology/paranatology, where a lot of children also die in those areas, and they have absolutely no facility whatsoever to preserve those infants immediately after birth and to save them.

These centers we are trying to develop from a foundation point of view, and we would like to obtain some help from the United States and other Russian countries to develop these centers to preserve those infants and children in general, and also develop a good, sound diagnostic hospital within these facilities that we are talking about so that you have an adequate type of procedure to do studies and diagnostic procedures.

Dr. METTLER. Can I make one point here? That is that I don't think anybody disagrees that the quality of medicine is a real problem in many areas, but let's just take this cardiac defect issue. You take children and you start looking at children, you're going to see defects that are sort of subclinical. There is no study in the scientif-

ic literature anywhere in the world that I'm aware of that shows an increase in cardiac defects as a result of radiation exposure. There's no study published anywhere that shows that. So I think that one of the issues—I mean, are we dealing with the medical problems in the Ukraine, which are substantial, to my mind really staggering, or are we dealing with a radiation effect? And I don't want you to mix up the two here.

Dr. WERTELECKYJ. I have to clarify this, because I don't think the point is well taken, because there are no such studies since you cannot subject individuals to radiation and because there are no published reports about heart defect issues. It does not mean that Chernobyl is absolved as a possible cause of such defects. There's a difference between no data and no effect.

Now, we cannot afford not to study Chernobyl, whether as members of the human race or as citizens of the United States. We have a poor understanding of carcinogenesis, cancer, and the effects of radiation. We are limited severely only to one study population of Nagasaki–Hiroshima, which is aging, otherwise we are to study experimental models.

I think that Chernobyl is going to teach us fundamental scientific facts that are going to benefit us and the rest of humanity. I think that investigators with the use of biomarkers and moleculor biotechnology are going to be able to unravel the differences of inherited and radiation induced cancers cancers. I think that Chernobyl is a unique opportunity, but we should not persue science without a parallel humanistic dimension.

Senator LIEBERMAN. Amen. I know we have to move on to the second panel.

Mr. Purvis, you're an engineer. I'm going to see if I can ask you to give me two numbers to questions. If I'm pushing you too hard, you have a right to remain silent.

[Laughter.]

Senator LIEBERMAN. The first one is you've expressed some concern about the stability of the sarcophagus that's been erected at Chernobyl. I don't know if you can do it numerically, but what is the likelihood that there may be a collapse there in the next 10 years?

Mr. PURVIS. As I understand it, the study that was done over there by the people who built it kind of attributed something like five years. It wouldn't be safe to wait for more than five years.

Senator LIEBERMAN. So in a sense they would warrant it for five years, but for no more?

Mr. PURVIS. It's kind of like you have a bad problem in your back yard and you go out one weekend and do something about it, and then you're going to do something permanent.

Senator LIEBERMAN. Yes, you know it's not forever.

Mr. PURVIS. And the temporary solution, as I understand the report, you might have five years.

Senator GRAHAM. And the temporary solution was applied when?

Mr. PURVIS. The temporary solution was in 1986, when the sarcophagus was built.

Senator GRAHAM. So it's been——

Mr. PURVIS. That's from, I guess—the study, I think, was in late 1990 or 1991. So you've got like until 1995. But the thing is, it's not

like on the 1st of January 1995 the thing will disappear. What you have is it's kind of settling, it's crumbling, there are lots of holes in it, the holes are getting bigger, it's rusting. It's just going downhill. It's not good now, and it's just getting worse. This study basically says they figure after about five years it will cross over the border.

Senator LIEBERMAN. And a collapse will run the risk of unleashing radioactive material again?

Mr. PURVIS. There are a number of things right now that have a risk of releasing it, and something like the top of the building falling in would definitely exacerbate the situation, yes, sir.

Dr. FESHBACH. A footnote, Senator, and that is I understand there has just been a contract let with some French construction company to build a containment structure just in the very recent past. So I don't know what their work schedule is, whether it will take five years, three years, et cetera, but that's my understanding anyway.

Senator LIEBERMAN. Thank you.

Mr. Chairman, one last question for Mr. Purvis, another hard one.

What are the odds that one of the other Chernobyl-type reactors that exist throughout the former Soviet Union will go in the next five years?

Mr. PURVIS. Well, I'll tell you a short story which just shows you about the dangers of prognostication. Back in April I was asked that question, and I said, "Well, the most likely accident to happen on an RBMK is a pressure tube failure. Those happen fairly frequently. The oldest plant and the one that seems to have the most problems is the near St. Petersburg. So if you ask me what's the most likely accident, it would be a pressure tube failure. If you ask me where, I would say at the plant near St. Petersburg." And five minutes later they had the pressure tube failure at Leningrad and the vent system plugged up, and that was the release this spring.

Senator LIEBERMAN. What's your prediction today?

Mr. PURVIS. You can talk in fact of the situation that there are a number of problems with those reactors. You can expect more pressure tubes to fail as well as other systems. I think you can expect to have a situation where the vent system stops up and a release of radiation results. There are a number of changes which have been identified which should be done and which would reduce the risk, in particular the possibility of the type of excursion that happened here. I simply do not know if all of those changes have been made on all of the reactors. I do know they've been made on some of them. That doesn't say that you won't have other accidents, like multiple pressure tube failures, which could in fact lead to significant releases.

The big problem, sir, is the quality of those reactors is bad. They've got some real quality problems as well as design problems. When you're dealing with something that's got quality problems, you're not quite sure what's going to fail or when.

Senator LIEBERMAN. Yes, and when we chronicle, as people are already doing, the characteristics of the corruption of a system of government and of the people's lives under Soviet power, this is one that's going to stand out. Clearly, there are so many ways in which people were coerced and controlled, but the decline in stand-

ards that led to a decline in the quality of life that led ultimately, in this case, to a tragedy which killed people and continues to threaten their lives is really a startling story. Anyway, thank you.

Thank you, Mr. Chairman.

Senator GRAHAM. Gentlemen, thank you very much. This has been an extremely constructive discussion and set of very helpful recommendations.

Our second panel will be Dr. Shelby Brewer, Chairman of ABB Nuclear Power; Mr. Gary Dunbar, Executive Vice President of Los Alamos Technical Associates in West Newbury, Massachusetts; and Mr. Thomas Garrity, General Manager of the Power Systems Engineering Department at G.E. Industrial and Power Systems, Schenectady, New York.

First, Dr. Shelby Brewer.

Dr. Brewer.

STATEMENT OF DR. SHELBY T. BREWER, CHAIRMAN, ABB COMBUSTION ENGINEERING NUCLEAR POWER

Dr. BREWER. Thank you, Mr. Chairman.

I have a written statement for the record, Mr. Chairman, and I will proceed for about five minutes or less with an overview summary.

Your invitation letter focused on Chernobyl and the Ukraine. I've taken the liberty of extending that subject somewhat to all of the Russian-origin reactors in eastern Europe and in the new Commonwealth, the former Soviet Union.

The Chernobyl accident has been very abundantly analyzed in terms of the dynamics of the accident, how the neutronics occurred, the design imperfections of the reactor, and the operating causes of the accident, and most experts agree that the accident resulted from an inherently very poor design combined with very poor and slack station operating procedures. There was no discipline in following procedures at the station. That combined with a very defective and illogical design were the root causes of the accident.

Most experts also agree that these design defects are so fundamental in nature that there is no way to retrofit them away. There is no set of equipment modifications or redesign that can be done on these reactors to bring them up to western standards. We're talking here about the fundamental configuration of fuel and coolant, the choice of materials, the way the dynamics of the system work. As a previous witness said, the stability issue, it has a positive void coefficient, which means as the core heats up, the power increases rather than decreases, as it does in American-designed reactors and other western-designed reactors.

Senator GRAHAM. Excuse me, Mr. Brewer, if I could interrupt. How many reactors are there currently in the former Soviet Union or elsewhere that would have the characteristics that you've just described?

Dr. BREWER. There are 11 RBMKs in the CIS. I have a table in my written testimony that shows the distribution of all reactor types. There are 16 total, and there are 11 in Russia, three in the

Ukraine, and two in Lithuania. That's the RBMK, the Chernobyl-type reactor.

So improving operating procedures, improving training, et cetera, improving station management, it is commonly felt by experts, will have little or no effect in terms of raising RBMKs to international and western standards, because you still have not licked these basic design-related safety problems.

For these reasons, most experts both in and out of the Soviet Union are practically unanimous in calling for the shutdown of RBMKs as soon as possible. I use the words "as soon as possible" because the RBMKs, with the statistics I've just cited to you, Mr. Chairman, do provide a fairly large fraction of the electrical demand in the CIS, particularly in Russia. But consider Lithuania. The two RBMKs in Ignalina, in Lithuania, supply about half of that country's electrical power, and Lithuania has no economy for substitution of generating equipment, shutting those reactors down and bringing other types of technology in. It has no indigenous fuel resources, so it's got a very tough problem in terms of the management of those two Chernobyl-type reactors. That's a reality one has to deal with.

Looking again at the total, one would say, "Well, let's shut them all down, and let's shut them all down now." We have to look at what is practical. Can you do that without impacting the electrical production and, therefore, the economy? Well, it turns out that electrical demand is decreasing in the former Soviet Union because industrial activity is down. How far will it decrease? Can you shut the RBMKs down and slide under the demand curve? I don't know, and they don't know.

There are other alternatives that should be enumerated and intensively reviewed by those republics. Efficiency improvements in the grid. Grid losses in that region run about 10 percent. That's the line losses, power lost in transmitting power from the generating station to its end use. Another alternative is repowering these RBMKs with fossil-fueled sources, as was done in Midland and Zimmer in this country. Wheeling power around the grid from places where you have excess capacity to where you have a shortfall, and a fourth possibility, longer-term, of course, is completing the latter day 1000 MWe VVER-type reactors, the pressurized water-type reactors that are approaching western standards. But the issue must be approached as a systems problem, an economic problem, supply/demand, look at alternatives for meeting demand, end-use efficiencies. And finally, how do these remediations get paid for? We must bring to this region, to the Commonwealth of Independent States and eastern Europe, means of entering the world economy to generate value to generate hard currency to pay for the reactor improvements that we, not they, insist on.

I'd like to turn now very briefly to the non-RBMK-type reactors, the pressurized water reactors, and there are several genre of pressurized water reactors. They are called VVER. They are similar in concept, but not detail, to the reactors that my company constructs, Westinghouse, and Frammatome. There are three classes of VVERs. Let's simply call them generation one, generation two, generation three. The IAEA, the USNRC, the U.S. Department of Energy, and the World Organization of Reactor Operators, a pleth-

ora of nuclear institutions, international and national nuclear institutions, have studied the VVERs very intensively technically, and these assessments are now forming the basis of the recommendations being made to G–7 and the G–24 committees for sponsoring assistance to that region and upgrading their nuclear infrastructure.

In general, and I will just draw you a cartoon on the general conclusions of these multitude of studies, first of all, the RBMKs are inherently unsafe and should be shut down, as I said, as soon as possible. That is a general conclusion. The second general conclusion is that the relative safety of this evolution of pressurized water reactors, as you would expect, the earlier ones are worse in terms of safety attributes, and the newer 1,000-megawatt models are relatively safer than the earlier ones. The third general conclusion is that all of the reactors, including the 1,000-megawatt VVERs, the latter, most modern design, fail to come up to western standards.

Another safety concern is that following the breakup of the Soviet Union, there is a prospective breakup of the nuclear infrastructure within eastern Europe. By that I mean in older days, before the breakup, the infrastructure was concentrated in Russia. That's where the designers were, that's where the engineers were, that's where the basic research institutions were, that is where the fuel for all of the reactors was manufactured and where most of the major components were manufactured. The safety concern is that now these assets are being decentralized. As Dr. Mettler on the previous panel said with regard to iodine measurements, everybody is doing things in a different way now. Well, in nuclear power, we feel that there is a great safety incentive for standardizing, for doing things in a uniform, standardized way.

Another safety concern is purely economic. The economic chaos in that region as the region moves from a military industrial complex, centrally planned and controlled economy, to market-driven economics, there is huge economic turbulence, and this is being felt in such things as the poverty of operators in nuclear power plants. And this is a safety issue.

So where does this all take us? First of all, safety solutions cannot be imposed. They have to be accepted by the recipient nations. We have to recognize energy supply/demand detail of each of the independent countries. Safety solutions cannot be imposed in isolation. There are alternatives, non-nuclear alternatives that must be factored in, such as conservation and increasing the efficiency of the grid and increasing end-use efficiencies.

A third conclusion I would reach is that we should encourage that region to do things regionally. For example, they don't need nuclear fuel manufacturing in each of the republics. It's not economic, and there are not enough engineering and expertise resources to do it that way.

A fourth recommendation I would have is that before we commit to billions and billions of dollars in reactor remediation, and I've heard estimates from $1 billion to $40 billion, a little bit more precision is required. That's a huge amount of money and a huge range of money to be throwing at a problem. I think immediate actions should be concentrating on operational safety. By that I mean

the training of the operators, establishment of operating procedures, etc.—the types of things we learned at TMI and applied after TMI.

Fifth, I think another component of the solution that we must rivet our attention on is how their economy can support these remediations. We must bring them not grants or aid money, but ways of generating the economy themselves, integrating them into the world economy with finished products as well as raw materials so that they can enter the 21st century with us.

Thank you, Mr. Chairman.

Senator GRAHAM. Thank you very much, Dr. Brewer.

Mr. Gary Dunbar, Executive Vice President, Los Alamos Technical Associates.

STATEMENT OF GARY A. DUNBAR, EXECUTIVE VICE PRESIDENT, LOS ALAMOS TECHNICAL ASSOCIATES, WEST NEWBURY, MASSACHUSETTS

Mr. DUNBAR. Thank you, Senator, for having me as your guest today.

Today I'd like to ask this subcommittee for active support in three important areas. Number one is the elimination of restrictions regarding the use of appropriated funds for activities involving the export of American know-how and technology for use in nuclear waste management, environmental remediation associated with radioactive releases, and in the safety and operating improvements for Ukrainian nuclear powerplants or other powerplants of the former Soviet Union. Those restrictions, an example of which is Public Law 101–513, section 510, restricting the export of nuclear technology, are major stumbling blocks to programs that we're currently talking about.

Number two is support for pending legislation for the Freedom Act. Specifically, we seek support for provisions of that act relative to Chernobyl that will facilitate environmental improvement activities, improvements to the safety of Ukrainian nuclear powerplants, and training of Ukrainians in areas which will aid the development of a market economy.

Number three, we seek encouragement and support for existing programs and institutions in the United States, such as the U.S. Trade and Development Program, Overseas Private Investment Corporation, the Export/Import Bank, and others that can be involved in the support of a Chernobyl comprehensive environmental remediation project.

Last September, right after the coup, I arrived in Kiev at the invitation of the Ukrainian government to talk to them about Chernobyl. The first thing I asked them was if I could see the master plan, and they looked at me with quizzical looks on their faces. There is no master plan. The testimony that we heard earlier today graphically illustrates that there is no master plan. There is a great deal of confusion. It's very unclear who is studying what. It's very unclear what is going on in Ukraine on the Chernobyl project.

Last week, on July 16th, our company completed negotiations with the Ministry of Chernobyl for a comprehensive Chernobyl en-

vironmental remediation project. This ministry of the government is responsible for the direction and coordination of all activities in Ukraine that relate to the Chernobyl accident. The Ministry of Chernobyl works with sister agencies, such as the Ministry of Environment, the Institute of Nuclear Safety, the Ministry for Energy, UkrAtom, and the Ukraine Academy of Sciences, but it is the central hub of the spokes on this wheel. The Ministry of Chernobyl coordinates the activities of the other agencies.

LATA completed negotiations, and that documentation is now before Vice Prime Minister Masik, before the Ministry of Justice, and before the Ministry for Foreign Economic Affairs for review.

This particular program is a little bit different than the others that you've heard about. Earlier testimony today talked about emergency measures that were taken immediately after the accident. Those measures included construction of the sarcophagus, the 800 burial sites for radioactive contaminated materials, and removal of populations from villages, evacuation, and things of that type. The second phase of activity that you've heard about is studies. There is a great deal of international study going on, and anybody who's been to Chernobyl runs into vans from all nations.

The program that we have worked out with the Ukrainian government, however, is a remediation program. It's a program not designed to study, not designed to take emergency measures, but designed to permanently resolve the issue. This program has been filed with the International Atomic Energy Agency in Vienna and has been filed with the Commission of European Communities in Brussels, and we have meetings scheduled with these organizations to review in detail their comments on this project.

Currently, LATA is scheduled to sign a contract with the Ukraine Government on the 5th of August that will launch this remediation program. We envision that early phases of the program would be supported by seed money from grant funds. The grant funds will be sought in the United States, from international agencies, and in Europe. Eventually, as a market economy evolves, the program calls for support by the sovereign debt capacity of Ukraine and operating funds of Ukraine, but that cannot happen immediately. There are many steps to go through to build up the financial structure to support this project.

The contract that we will sign next week covers the first 10 years of remediation activity. We have had discussions envisioning a 30-year program to completely eliminate the consequences of the accident at Chernobyl.

The program is "comprehensive." It's a word they selected in the very first letter of invitation that they sent to us. There were four reactors operating at the time of the accident, with two more under construction. One blew up, three continued to operate until a fire last October, when number two went down, and now the other two have been turned off. The program covers the accident site as well as the three remaining reactors at the Chernobyl site. Although the three remaining reactors are not operating, they do have to be decommissioned and demolished.

In regard to reactor site number four, which is the reactor that blew up, the program covers the migration of contamination. This map will give you a superficial understanding of this very complex

issue. The directions that the wind blew the material are exactly the opposite of where water is taking the contaminated material. The water flow through ground water and surface water will gradually move the contaminated material down through the Dnieper River, to the Black Sea, to the Mediterranean.

The remediation program covers agricultural and food supply, contaminated water, contaminated soils, nuclear waste management, and health effects. It's a management program designed to pull these various activities together and to coordinate them toward the single goal of dose reduction to the population.

The program will utilize services of at least nine American companies, 30 colleges and universities, Sandia National Laboratories, as well as several other United States national laboratories. It will also facilitate the establishment of private Ukrainian companies that will implement major portions of this work. It will set up a basis for Ukrainian companies to compete for contracts and execute work. It will also set up international competitions for specific projects. The program is envisioned to create jobs in export markets for Americans as well.

The Chernobyl accident, with its physical, environmental, health, and psychological aspects, is the single most significant obstacle to Ukraine emerging into the world economy and fully realizing its potential as a nation. If you travel around Ukraine, you can't help but be struck by the inherent wealth of the nation. It is a nation of great resources, a very strong people, a very well educated people. Perhaps the most baffling achievement of the 70 years of the previous government's rule is how you could run any nation with that potential and end up broke. You really had to be creative to squander the resources. If Ukraine can get on its feet, it should end up being a wealthy nation and it should have the capacity to address its own problems.

Senator GRAHAM. I'm afraid if we look around the world, we could find a lot of examples of countries that are in the process of squandering their resources.

Mr. DUNBAR. Well, the agricultural resources alone here are mind-boggling, and how you can have the potential to consistently produce one ton of wheat per person and be an exporter of food and still end up busted is remarkable. Anyway, we are not here to debate that.

The accident has dramatically reduced the supply of electrical energy. It reduced the production and supply of healthy food. And as we've heard from others, and I have witnessed personally, it's had a phenomenal impact on the attitude and morale of Ukrainians. We as Americans can help Ukraine. We can help them help themselves. Within the Ukrainian effort, the current effort that they are going through, to face their problems and to resolve them, they will inevitably look to other nations and adopt a model for nuclear materials management and nuclear regulation. That process is evolving now. It is not a highly structured one, but it nevertheless is evolving. Any approach that they undertake to resolve their nuclear issues will address Chernobyl first. It will be the foundation and the building block from which everything else evolves.

The nation that Ukraine eventually adopts as a model for nuclear management will also end up as a major supplier of technical

know-how, technology, and assistance. Those things will go hand in hand. Many countries might serve as that model. Indeed, the United States could be that model. If we end up being that model, we end up also being a major exporter of environmental and nuclear technology and know-how to Ukraine. It goes hand in hand.

Our program for Chernobyl, we believe, is a first important step along that path. As Americans, we offer Chernobyl unique advantages that are absolutely unmatched by any other country. We have a half-century investment in nuclear science and engineering that has produced an asset that is unsurpassed. We have programs in environmental management and remediation that have led the family of nations over the past three decades and have created within the United States another technical and knowledge asset. Our skills in program management and project management generically are about the same as they are in any other nation, but in the areas of nuclear and environmental concerns, they stand head and shoulders above. Finally, the way the world economy has turned recently, we Americans end up now being the low-cost provider. Engineers and scientists from Germany, France, and Britain all cost more than the American engineers and scientists.

As businessmen, we see ourselves with an advantage in the competitive world. We have a situation where there is a great deal to be gained. As Americans, we have an advantage to take an action now that is morally correct in Ukraine. We have an advantage to provide humanitarian assistance. We have an advantage to help Ukraine move into a market economy. We have an advantage to build a long-term relationship with a nation that should be a strong nation and a good citizen of the world, and a relationship that would be advantageous to our country. And we have an advantage to help ourselves as we help others. I hope we take advantage of our opportunity.

Thank you.

Senator GRAHAM. Thank you, Mr. Dunbar.

Mr. Garrity.

STATEMENT OF THOMAS F. GARRITY, GENERAL MANAGER, POWER SYSTEMS ENGINEERING DEPARTMENT, G.E. INDUSTRIAL AND POWER SYSTEMS, SCHENECTADY, NEW YORK

Mr. GARRITY. Thank you, Senator.

I'd like to open by extending my thanks to the subcommittee for its work in assembling this panel of experts to discuss the possible solutions to the Chernobyl accident. I'd also like to express on behalf of the General Electric Company our gratitude for the opportunity to offer our expertise and technical insights.

As we've heard this morning, Chernobyl was the world's single greatest nuclear reactor accident. The exact toll in human and environmental damage may not be known for many years. Based on what we read and analyze, it is apparent that the reactors of the Chernobyl type were designed and constructed far below even the earliest western technology standards. This is a critical issue, because as many as 16 reactors of the same design are still operating in the Commonwealth of Independent States.

Further, there is no easy way of upgrading the safety systems of these plants. Lacking the necessary technical knowledge of these specific plants, such an endeavor by the General Electric Company would be very impractical. What we do recommend, though, is an in-depth review of alternative forms of energy that could eventually replace these nuclear plants in the Commonwealth of Independent States.

This is not the first time that we have offered our assistance to deal with possible solutions to alternative sources of energy production following the Chernobyl accident. We entered into very active discussions on this topic in both 1989 and 1990. We discovered, however, that there was no commercial basis available to fund any support we might have been able to provide. We do see two encouraging signs in the CIS that make such a venture more plausible of recent.

The first is a trend toward more stability in the region's governmental structures that may make it easier to pursue future arrangements for assistance. The second is renewed focus on the Chernobyl crisis on the part of the industrialized nations. It's encouraging, for example, that although the leaders of the G–7 nations did not grant the $700 million emergency fund requested at the recent Munich Summit, they did approve a fund of $100 million to carry out the appropriate emergency measures. We hope that this type of attention to the problem continues toward what is clearly an environment and health disaster waiting to happen.

It is our position that proven western technology possessed by G.E. and others already exists that can provide large blocks of electric power in a clean, efficient, cost effective, and environmentally compatible manner and prevent most of any type of future disaster. Today I'd like to give you a brief look at these technologies and discuss why they are best suited to meeting the current needs of the CIS. Before doing that, however, I'd like to take a moment to convey what we perceive as our role and, perhaps more importantly, your role in helping provide safe and economical power to the Commonwealth of Independent States.

Two obstacles have existed in dealing with the Commonwealth of States to serve this critical need for power. The first is political, and the second is technological. The political instability in the Commonwealth recently coupled with the inability to meet commercial terms has made it virtually impossible for G.E. or any other company, for that matter, to successfully enter into any agreements on their own for supplying power equipment to the CIS. What's needed is your assistance in contacting the appropriate parties, making the appropriate diplomatic arrangements, and facilitating the needed political mandates that will allow G.E. or any other power equipment supplier to do business in the Commonwealth.

The technological side of the problem is our responsibility, and we're more than up to that task. We have technology available that will capably and completely support any energy option deemed necessary, and we're prepared to offer recommendations on what options best match the needs of the Commonwealth. We would be more than willing to combine our technological expertise with governmental support to form a type of super joint venture

that would greatly benefit the Commonwealth, as well as U.S. industry and trade.

The need is urgent. An ideal window of opportunity for providing power equipment to the Commonwealth is now open and may not come again for quite some time. Overall power consumption is down some 30 percent due to the shutdown of many military facilities in the region and reduced industrial output. This is a prime opportunity to move the Commonwealth away from the substandard technology that they now rely upon for their energy to cleaner, safer, and more cost effective forms of power. I urge you to not let this opportunity slip away.

Looking at the technologies available, they range from potential long-term remedies, such as safe nuclear power, to short-term faster fixes, such as fossil fuel plants and advance combined-cycle applications fueled by natural gas. In the area of nuclear energy, new advanced technologies are being developed that will provide environmentally compatible, more economical nuclear power with greater levels of safety. At GE, for instance, we are working on two advanced light-water reactor designs sharing a common technology base. These new technologies incorporate the best proven features from 35 years of boiling water reactor designs and employ newly developed controls and instrumentation, fuel and turbine technology, and advanced simplified accident mitigation techniques for maximum safety.

However, G.E. does not regard western-type nuclear power plants as a near-term solution to the former Soviet Union's power needs; rather, at most, one of several potential solutions. Fortunately, other globally accepted sources of power generation are available to meet the region's needs. For example, G.E. offers the latest steam turbine technology using ultra super-critical steam conditions with operating temperatures up to 1,200 degrees Fahrenheit as well as having the largest installed base in the world.

While steam turbine technology offers many advantages, the best solution for the Commonwealth in the short term is the advanced combined-cycle application. Current combined-cycle plants are an extremely efficient energy option, operating at thermal efficiencies approaching 55 percent, and we believe 60 percent is obtainable within this decade. Overall advanced combined-cycle technology would be able to address the energy needs of the Commonwealth in a very quick and economical manner. We strongly recommend this course of action in the near future as the best way to take advantage of the window of opportunity I spoke of earlier.

Looking at what we view as the bottom line in the Chernobyl situation, the need is great and the time is now to move toward assisting the Commonwealth with their clearly precarious energy situation. What we and other industries require from this body is assistance with helping to handle the political implications of such an endeavor, and we certainly defer to your expertise in this area. Ours is a technology mandate, and we have no doubt we can deliver in that area. The political mandate falls to you.

We would welcome the opportunity to join forces with the U.S. Government in helping provide the Commonwealth of Independent States with safe, reliable, and cost effective energy options now and into the future.

I thank you for your attention.

Senator GRAHAM. Thank you, Mr. Garrity.

Dr. Brewer, you talked about the collapse of the infrastructure for nuclear power in the former Soviet Union and in eastern Europe. Do you believe that that collapse has increased the risk of another Chernobyl?

Dr. BREWER. Yes, I do. As you may recall, before the collapse of the Soviet Union itself, civilian nuclear power was administered by an agency in Moscow called MAPI, Ministry of Atomic Power and Industry. When the Soviet Union broke up, their responsibilities were then confined to Russia. The Ukraine is setting up its own nuclear ministry and so forth, and the other states are doing so as well. So you have on the one hand a decentralization and democratization of the country.

On the other hand, you have the transient period here where there's some time before the other republics can get their nuclear expertise up to grade that they had formerly been relying on the centralized agency to provide. And the other problem with this decentralization is economic—there are some economies of scale in having reactor expertise centralized and fuel cycle facilities centralized as long as their quality can be improved, but I don't see the decentralization of these institutions and these functions as a positive safety factor. It's a disruption, particularly now with the general economic situation so chaotic.

Senator GRAHAM. Do you see any greater capability of dealing with Chernobyl today than was the case in 1986?

Dr. BREWER. Yes, the emergency procedures in eastern Europe and the former Soviet Union are far, far improved. They understand the need for emergency procedures. They understand the need for standardization of these procedures and training and so forth. Responding to an accident of that magnitude from the station perspective is orders of magnitude better than it was in 1985–1986.

Senator GRAHAM. Each of you has touched upon the issue of the United States' role both from a scientific basis and also in terms of our economic opportunities that exist. At the recent Rio conference, there was a section within one of the treaties called Agenda 21 that related to nuclear power. If you're familiar with that, do you have any comments about that particular provision? There's also been a suggestion largely at the instigation of the Germans that there be a more detailed convention on the international issues of nuclear power, with particular attention to the former Soviet Union. Assuming that there is going to be such a convention, what do you think the U.S. agenda should be at that meeting in terms of advancing our national economic and scientific goals?

Mr. GARRITY. Well, speaking to the issue of the nuclear power option, it has been our position that the western technology and the very high safety standards that are being incorporated in the next generation of advanced light-water reactors both by my company and by ABB and by Westinghouse and others I think does speak well to the future safety and the future potential of that energy source to address some of the other issues relative to combustion of coal and natural gas and oil for power production in terms of limiting the CO_2 emissions as well as other greenhouse

gas emissions. So we think that the opportunity to consider and to utilize nuclear power as another option for the future worldwide production of electric energy clearly is one that should be put forward as one of the prime candidates.

Likewise, we would support the other alternatives for cleaner combustion, clean coal technologies, what have you, development of more efficient power production facilities, conservation, and development of renewable technologies. We think the energy equation requires a balance of all of those alternatives, and that is the true solution, I think, from a global point of view.

To the question of the Soviet reactors, I share Dr. Brewer's concern about the current RBMK-type reactor that they are substandard, and we do have an opportunity and a near-term solution that is available that would be and could be directed toward shutting those units down and safely decommissioning them. It will take some effort on export guarantees and other types of instruments to assist companies such as ours to participate meaningfully in that opportunity. There have been some encouraging signs recently in the EXIM Bank opening up several offices and moving into the former Soviet Union. We would encourage and actively support increased appropriations to such agencies as EXIM Bank to back up those export guarantees that I mentioned.

Mr. DUNBAR. Just to address your comment on the Rio conference, I know nothing about the agenda you were talking about, so I won't comment on it. If we look at the former Soviet Union right now, we see countries where there is economic disarray. It is hard to tell how many rubles or Ukrainian coupons you're going to get for a dollar in any given week. Last week I went from 115 to 130 to 145 while I was in Kiev. The economy is in a mess. People don't know how much money they earn. They don't know how much things cost. The average person, despite great increases in salary, still can only buy about 200 loaves of bread a month. Two hundred loaves of bread in the United States cost about $200, so everybody just mentally measures his own take-home pay and finds out what his comparative wealth is.

If that situation, if that mess with economics was combined with an absolute removal of energy supply, of electrical energy just disappearing, we would be taking a family of nations and casting them into some kind of a dark ages. Now, so far we've gotten through this breakdown of communism and a transition in the Soviet Union without widespread war and without widespread chaos. Tragic wars have broken out, but not to the degree that could have been. But if you remove electrical energy production capacity from those countries by not taking action, then I can't begin to imagine what happens.

It's a stressful situation for people now. They have the stress of Chernobyl, which put society into turmoil. They have the stress of a total economic and political change, and the energy supply is very threatened. Ukraine now produces about 9,000 megawatts of electrical energy from nuclear powerplants, based on the inventory I did last week in Kiev. I've been working with UkrAtom in Kiev to try to confirm my data. The Chernobyl accident alone removed from energy production capacity 9,000 magawatts—four plants at Chernobyl, two that were under construction, and three more

VVERs that have not been turned on because of the political consequences.

Now, here we have three of their newest, theoretically safest versions of the VVER powerplants that they can't throw the switch on because of the phobia over Chernobyl. There's 3,000 megawatts of energy that would be a 25 to 30 percent increase in the total supply. The existing plants that are operating—well, three went off-line last year, and every day that goes by, the potential for turning off more plants grows, because they need equipment, they need training, they need every basic aspect of building the power and energy infrastructure.

So I think in terms of priorities, some kind of a measure to hold the Nation together is imperative. If it falls apart, it has consequences for not just Ukraine and Byelorussia and Russia and the others, but it has consequences for Europe and the United States.

Senator GRAHAM. One last question before turning to Senator Lieberman. To what degree do you think the United States should be approaching this bilaterally or through international agencies, and if international agencies, which existing agency would you have most confidence in, or will there be the necessity of creating new multinational structures to deal with the new conditions?

Dr. BREWER. Well, let me take a stab at that, Mr. Chairman. There are so many entities and States and agencies and companies trying to assist that region in nuclear power that it has become very redundant, will become wasteful as big money starts flowing, and all of these entities are very well meaning, but there's also a lot of ambulance chasing, and it must be coordinated.

Senator GRAHAM. So is your summary that there needs to be more international agency intermediation?

Dr. BREWER. I wouldn't say any more international agencies, but I think the IAEA is probably the logical international body to help the former Soviets set priorities on what needs to be done first, second, third, fourth, and not done at all.

Mr. DUNBAR. I'll just add to that. My firsthand experience as a United States businessman is we compete in a world where the collaboration between government and business for our competitors ismuch closer and much more well orchestrated than it is for ourselves. I meet competitors in the former Soviet Union, and the support that they have, direct hand-in-hand support, both in money and technical support, from their governments, far outstrips our traditions of how business is done. So when money goes into an international pot, when the United States taxpayers' money goes into an international pot to be distributed, this United States competitor sees himself at a disadvantage.

Mr. GARRITY. Senator, I'd just like to add to the previous two speakers' comments and in fact support the IAEA as the overall coordinating agency for the standardization of upgrading or decommissioning of the Soviet reactors. But likewise, I do share a similar concern as Mr. Dunbar relative to the competitive environment that we do work in, and as I suggested, I think some form of export guarantees in the form of additional support to EXIM Bank, and we, then, as a private industry working globally can successfully compete both technically and commercially.

Senator GRAHAM. Senator Lieberman.

Senator LIEBERMAN. Mr. Chairman, you and the witnesses really covered the questions I had, and I'll just therefore make a very brief comment.

Obviously, there are big numbers monetarily, economically involved in responding to Chernobyl and all the other reactors that we're worried about as a result of Chernobyl. I hope that the Ukrainian government shares your evaluation of the priorities here, Mr. Dunbar, that this is really right at the top, and that with international help and as the Ukrainian economy gets on its feet that there will be money to support these efforts.

Then, of course, there's the other side of it, which you've all just spoken to in response to the Chairman's question, which is, how do we on behalf of American business workers, as the expression goes, not only do good but do well? I mean, not only help them out, but create some economic opportunity for American companies?

I'm troubled though not surprised to hear your response that we're not only in a competitive environment, but we're in a competitive environment over there in which you too often are competing without as much support as your government as your foreign competitors are getting from their governments, and I would invite any—I hear the message about EXIM Bank financing, and I'd invite anymore specific suggestions you have as to how we can be of help to you.

In your statement, Mr. Dunbar, you made reference to some laws and regulations that may be restricting the export of some cleanup technologies. I think if you can pinpoint those, maybe we can try to see if we can eliminate them.

Mr. DUNBAR. Well, I'm fearful that there may be several, but the example that has most recently come to our attention is Public Law 101-513, section 510, which reads, "None of the funds appropriated or made available pursuant to this act for carrying out the Foreign Assistance Act of 1961 may be used to finance the export of nuclear equipment, fuel, or technology." Our experience in dealing with agencies of the United States Government is, that over the past year, this law has been interpreted to include environmental remediation and safety improvements to operating reactors and various things that are related to that.

Senator LIEBERMAN. Which sure doesn't sound like what the original intention was.

Mr. DUNBAR. Well, we don't think it was the original intention, but no matter what the original intention was, the whole world is now different, and we think this law needs to be revisited. We understand it has come up in the Freedom Act and amendments have been placed before Congress in that act to search out laws of this type and address them, and I hope that is forthcoming.

Senator GRAHAM. I would imagine that as a residue of the Cold War era that we've got provisions like that scattered through many places, and what we need now is first a gathering of those and then an assessment of whether they continue to be in the national interest, given the conditions that exist today as opposed to the conditions at the time they were adopted.

Senator LIEBERMAN. Perhaps we can do that through the subcommittee. I thank the three of you, and again, Mr. Chairman, I

thank you for convening this hearing, which I think has been very instructive and constructive.

Mr. DUNBAR. Can I say one more thing?

Senator LIEBERMAN. Sure.

Mr. DUNBAR. Just as a matter of fact to bring you up to date, no contract has been signed with anyone as of last Thursday to do anything about the sarcophagus. A week ago Thursday there was an international meeting where a competition was announced, and there is a schedule to sign a contract next year sometime regarding the sarcophagus, but it is a confused situation, and if you had three more hours I would try to explain it to you, but you still wouldn't understand.

Senator LIEBERMAN. I have the feeling I should be grateful that I don't have the three hours.

[Laughter.]

Senator LIEBERMAN. Thank you.

Senator GRAHAM. Gentlemen, thank you very much. This has been a very constructive meeting and raises in the specific context of nuclear safety some of the most fundamental questions of the future of U.S. relations with our former adversaries, the U.S. role both from the sense of humanitarian responsibility, science, and economics in the next generation of environmental issues that the world will have to contend with, and the question of how do we advance our own national agenda by an appropriate role in this very fragile area of the world.

I thank each of you for your contributions and look forward to continuing this what I imagine will be a very long-ranging set of U.S. interests and involvements.

[Whereupon, at 12:46 p.m., the subcommittee adjourned, to reconvene at the call of the Chair.]

[Statements submitted for the record follow:]

The Children of Chornobyl Relief Fund

TESTIMONY OF

ZENON MATKIWSKY, M.D.

PRESIDENT OF

THE CHILDREN OF CHORNOBYL RELIEF FUND

BEFORE THE

SUBCOMMITTEE ON NUCLEAR SAFETY,
SENATE COMMITTEE ON THE ENVIRONMENT
AND PUBLIC WORKS

JULY 22, 1992

272 Old Short Hills Road, Short Hills, New Jersey 07078 201-376-5140; Fax: 201-376-4988

INTRODUCTION

My name is Dr. Zenon Matkiwsky. I am the Chief of Surgery at Union Hospital in Union, New Jersey. Today I will address this Committee in my capacity as the president and co-founder of the Children of Chornobyl Relief Fund, a humanitarian relief organization based in Short Hills, New Jersey, with 30 affiliates nationwide.

I am a Board-Certified member of the American College of Surgeons, an Assistant Professor at the New Jersey School of Medicine, and I am serving on the Multi-Specialty Advisory Committee of the State of New Jersey. I am a graduate of the Pennsylvania Military College and the Philadelphia College of Osteopathic Medicine. Since 1990, I have travelled to Ukraine on 14 separate occasions, to personally evaluate the medical condition of children in hospitals in six different cities. For more information on the Children of Chornobyl Relief Fund and its experience in Chornobyl relief work, I have attached a two-page outline of our activities over the past two years.

We are grateful to the Committee, and to Senator Lieberman in particular, for giving us the opportunity to present this testimony, and to address the critical issues involved in the aftermath of Chornobyl.

It has been six years since the accident at the Chornobyl nuclear power station. This tragedy has inflicted irreparable damage on some of the most fertile and productive territories of Ukraine and southern Belarus. It is also expected to have a profound effect on the health, ecology, and economy of the entire world.

Tremendous costs have been expended on the "liquidation", or to be more exact, on the containment and minimization of the disaster's after-effects. Expenditures for radiological protection of the public are expected to run into the hundreds of billions of roubles.[1] Given the depth of its economic crisis, Ukraine cannot cope with this massive problem alone. For a nation which has just achieved its independence, and has begun to free itself from the remnants of a communist regime, Chornobyl has imposed a tremendous and crippling burden.

Yet to treat this as a uniquely Ukrainian tragedy would be an error. Large concentrations of radiation and radioactive hot spots settled hundreds of miles away from the reactor, in Finland, Ireland, Italy, Norway, Poland, Sweden, Turkey, Wales.[2] In a

1 V. A. Knyzhnikov. "Radiation Safety on the Contaminated Territories of the Chernobyl AES; A Circle of Severe Surrounding Problems", Medical Radiology Journal, No. 1, January 1992.

2 Anspaugh, L.R.; Catlin, R.J.; Goldman, M. "The Global impact of the Chernobyl reactor accident". Science 242 (4885) 1513-1519. (1988). Gilmore, B.J.; Cranley, K. "Radionucleide monitoring in Northern Ireland of the Chernobyl nuclear reactor accident". Ulster Medical Journal 56(1). 45-53 (1987).

very real sense, Chornobyl is the world's problem. The plight of its victims has become a moral issue which transcends national boundaries , and calls for international solutions.

For years, the Soviet regime maintained that only 24 to 34 people died as a direct result of the Chornobyl meltdown.[3] As late as 1990, the Communist Health Minister of Ukraine, Mr. Romanenko claimed that only 209 persons have suffered illnesses related to Chornobyl's effects.[4]

The stubborn deceit involved in the Soviet coverup of Chornobyl is now coming to light, as we gain access to newly declassified documents from the Kremlin which show that not 34, but as many as eight thousand persons -- mostly nuclear clean-up workers may have already died as a result of radiation exposure in Chornobyl.[5] An article published in April of this year, in "Izvestiya" reveals excerpts from secret protocols of the Soviet politburo which directly contradict the public pronouncements of Soviet authorities in the spring of 1986.[6]

We now know that the Politburo was receiving daily updates on thousands of clean-up workers and hundreds of local children who were hospitalized with radiation sickness, even while publically, Soviet officials were telling the world that the health impact had been grossly exaggerated by the Western press.[7]

Even if we considered the first weeks following the accident in isolation, Chornobyl would rank as one of the single greatest ecological disasters of this century. Unfortunately, the real long-term tragedy is just beginning to unfold.

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3 "Chernobyl Said To Affect Health of Thousands in A Soviet Region", New York Times, November 3, 1991.

4 Alla Yaroshin'ska, "Forty Secret Protocols of the Kremlin's Wisemen", Izvestiya, April 25, 1992. Romanenko's assurances are still being echoed by a number of Western experts, including Dr. Marvin Goldman, professor of radiation biology at the University of California at Davis, and director of a Soviet-American program on health effects of nuclear operations. New York Times, supra.

5 "Chernobyl disaster worse than reported", Los Angeles Times, April 14, 1992. See also: Medvedev, Z. The legacy of Chernobyl. New York, W.W. Norton, 1990. Davis, A.M., "Health Care After Chernobyl: Radiation, Scarcity, and Fear", The PSR Quarterly, March 1922, Vol. 2, No.1. Davis and Medvedev lend credence to the higher death estimates in that at least 3,400 persons were sent on brief runs across the roof of the reactor, to pick up radioactive debris and bits of graphite fuel with their bare hands. Radiation fields in this area reached as high as 10,000 rads per hour . "Some of these workers may well have received lethal doses, but were cared for in military...hospitals where their illnesses were either misdiagnosed or covered up."

6 Yaroshin'ska, supra, note 4.

7 Ibid

The Ukrainian Ministry of Health has reported a tripling of cancers among Ukrainian children since 1986.[8] (See graphs attached.) Most disturbing among these is the sharp increase in thyroid cancer among children.

In the Kiev Research Institute of Endocrinology and Metabollism, the number of operations performed on children with thyroid cancer has gone up from an average of two per year, to twenty in 1990, and thirty more in 1991.[9] Our own National Institutes of Health have expressed grave concerns about the growing number of confirmed reports of thyroid cancer among small children in northern Ukraine and southern Belarus.[10] This is an extremely rare form of cancer, that is hardly ever encountered in children in the West.

In the hospitals sponsored by our Fund, hematologists have also noticed a dramatic increase in the number of new leukemia cases diagnosed since 1990. This would be consistent with the latency period between initial radiation exposure in 1986, and the point at which leukemia develops.[11]

We are also deeply concerned about the rapid increase in health problems affecting pregnant women and newborns in Ukraine. According to the Kiev Institute of Pediatrics, Obstetrics & Gynecology, the rate of miscarriages has more than doubled since 1986, and the mortality rate among women during delivery has also increased dramatically.[12] (See attached charts.)[13]

Now, we realize that some of the information we are receiving is anecdotal and problematic. ALL of the reports that have been issued on Chornobyl to date call for more research. Yet there is broad concensus that the general state of health throughout Ukraine has deteriorated badly since 1986, and Ukraine is in dire need of antibiotics, anti-leukemic medicine, and diagnostic equipment, as well as drastic improvements in prenatal and neonatal care, family planning, and nutritional supplements.

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8 Official Report of the Ukrainian Ministry of Health, 1991.

9 Ibid.

10 Letter from Jacob Robbins, M.D., Chief of Endocrinology Section, National Institutes of Health, Department of Health & Human Services, dated February 21, 1992.

11 Davis, supra, at 19: "Given the latency of radiogenic leukemia incidence (onset at two or three years, peaking at seven to eight years, and elevated, but trailing off over at least 35 years)...the threat of cancer likely will hang over individuals in exposed populations for life."

12 Shkiryak-Nizhnik, Z., "The Medical Aftermath of the Chornobyl Disaster", Lecture before the Boston University School of Public Health, May 22, 1992.

13 Official Report of the Ukrainian Ministry of Health, 1991.

Health officials have been bending over backwards not to attribute this generally worsening situation to radiation alone[14], but at the very least, we believe that Chornobyl has been a major contributing factor.

We are particularly disturbed by new studies released at a Kiev medical conference convened last April, which show that the number of genetic malformations among newborns throughout the republic has gone up from 13,000 in 1985, to more than 14,400 per year between 1987 and 1990.[15] There is also growing evidence of extensive chromosome changes and the potential for long-term genetic damage affecting persons living in the Chornobyl region. A highly detailed study of German citizens returning from the vicinity of Chornobyl following the 1986 accident has documented a dramatic increase in structural chromosome aberrations,[16] and hematological changes in the blood of children who permanently reside in radiation-contaminated territories is significantly higher than the levels shown in children from Kiev."[17]

The dramatic health situation which is unfolding in Ukraine is being disputed by a health commission formed by the International Atomic Energy Agency, which was invited by the government of the former USSR to analyze various issues associated with the Chornobyl accident in 1991.[18]

It is widely known that the commission was composed of authoritative scientists from many nations, and we need to give due acknowledgement to their qualifications. However, the Commission was faced with objective difficulties, namely constraints on cost, time, and necessary equipment, and these conditions forced this team of scientists to rely in part on information provided by the Soviet government -- most notably,

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14 Ibid., Marples, supra.

15 Id.

16 Stephan, G.; Oestreicher, U. "An increased frequency of structural chromosome aberrations in persons present in the vicinity of Chernobyl during and after the reactor accident. Is this effect caused by radiation exposure?" Mutation Research. 223(1), 7-12. (1989); see also BEIR-V Committee Report (Biological Effects of Ionizing Radiation), National Research Council, (National Academy of Sciences)

17 Kindzelsky, L.; Zvirkova, A.: "Indicators of Blood Disorders In Children Living In Areas Contaminated by Radionucleides Following the Chornobyl Accident"; Kiev Institute of Oncology/Kiev Institute of Hematology (1992). See also: "Ecology's Eastern Front", U.S. News & World Report, July 20, 1992, page 43, which cites Chornobyl as a suspected cause of deformations in three children recently born without eyes in northern Norway.

18 International Advisory Committee. The International Chernobyl Project. Assessment of radiological consequences and evaluation of protective measures. An overview. Vienna: International Atomic Energy Agency, 1991.

information on the actual doses of radiation released, and the estimated exposures.[19] Due to lack of time, I cannot dwell on all the details of the IAEA study, but we need to draw attention to the fact that the IAEA commission worked under circumstances dictated by a secretive regime which had oversight authority over the Chornobyl problem.

Just as the IAEA has had to abandon some of its conclusions about the safety of RBMK reactors,[20] we are confident that the IAEA will also re-think some of its conclusions about the health situation in Ukraine, once its has reviewed new documents which were not available at the time of its initial study. Let me just cite the following example:

In September of 1991, (6 months after the IAEA report was completed), the office of the federal prosecutor of the USSR addressed the sale of 47.5 thousand tons of meat, and 2 million tons of milk produced between 1986-89 on contaminated territories. The politburo's (secret) memorandum admits that the radioactivity of these products substantially exceeded the maximum permissible limits which, in May of 1986, had been relaxed by fifty-fold on the recommendation of the Soviet Health Ministry.[21] In another of the Politburo's recently declassified protocols dated August 22, 1986, Izvestiya reveals that the Soviet Health Ministry ordered some 10,000 tons of contaminated meat to be distributed to meatpacking plants around the country, and "to use it for the preparation of sausage products.... at a ratio of one to ten with normal meat".[22] Yet the IAEA concluded that "Doses actually received due to the ingestion of contaminated foodstuffs was substantially lower than the prescribed intervention levels of dose, typically by a factor of 2-4, and as a consequence, foodstuffs may have been restricted unnecessarily."[23]

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19 Ibid., at p.3: "The International Chernobyl Project was not intended to have the rigor or the comprehensive scope of an elaborate, long-term research study. Nor was it even remotely intended to duplicate the voluminous existing assessments of the environmental contamination, the radiation exposures of the population and possible health effects due to exposures resulting from the accident...."

20 Marples, D.R.: "Chernobyl: Five Years Later", Soviet Geography, May 1991, pp. 291-313. (See especially subsection entitled: "A New Interpretation of the Accident", pp. 292-294. "Chernobyl's 'Shameless Lies'; Ex-Engineer Denounces Official History", Michael Dobbs, The Washington Post, April 27, 1992.

21 Yaroshinska, supra, Izvestiya, "Forty Secret Protocols..."

22 Ibid. It is interesting to note that the protocol specifically excluded meatpacking plants in the Moscow area from receiving a fair share of the contaminated meat.

23 International Advisory Committee, supra, at 43.

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The conclusions offered by the Commission have cast doubt on the necessity for carrying out further protective and prophylactic measures, and IAEA researchers were quick to blame "radiophobia", hysteria and psychological stress as major health problems, to offset reports of increased cancers, and serious health effects.[24] The scientists of the IAEA did not know, and could not have known in 1991 some of the crucial facts which were being concealed, or filtered through the control of the Communist Party.

The deceit surrounding the accident at Chornobyl was as global in scope as the global nature of the catastrophe itself. Today, you have before you newly declassified documents, recently published in the official press which reveal some of the secrets surrounding the early months of the Chornobyl disaster. These documents saw the light of day in November of 1991 -- more than half a year after the IAEA released its report. We need to draw attention to the fact that the IAEA commission did not have the benefit of these documents before issuing its report.

We should also note that crucial information about the first weeks following the accident was controlled by a secretive regime, which ordered physicians to alter the death certificates of Chornobyl clean-up workers, and to misdiagnose cancers or other radiation-related illnesses. We need to remember that "radiation illness was not permitted as a medical chart diagnosis in Ukraine for the first few years after the accident".[25] Any speculation about radiophobia, and the possible exaggeration of health effects needs to be considered against the backdrop of a massive and indisputable coverup of Chornobyl which for six years, severely **under-counted** radiation effects, and falsified the medical history of Chornobyl's earliest victims.

A number of scholarly assessments and assumptions about Chornobyl have been based on theoretical models patterned after the Japanese experience following the atomic bomb blasts in Hiroshima and Nagasaki. On a number of levels, such models and comparisons can be problematic, if not inappropriate .[26]

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24 Ibid.; New York Times, November 3, 1991, supra.

25 Davis, supra, at 7: see also: "The Chernobyl Cover-Up", TIME Magazine, November 13, 1989, page 62; Marples, D. "Chernobyl: Five Years Later" supra, page 300; Kovalevska, L., "Chernobyl, FOR OFFICIAL USE ONLY", Kiev News, No. 1234, (April 16, 1992); Chernousenko V., Lindley R. This Week, "Coverup at Chernobyl: the bitter legacy". London, U.K., Thames TV; (April 25, 1991).

26 Marples, D. R. "The Chornobyl nuclear disaster: a Western perspective"; The Ukrainian Weekly, April 21, 1991.

First, it is well known that within the set of life-threatening components of atomic weaponry, only 20% of the overall impact stems from the radiation factor. The major destructive factor (80%) is the actual bomb blast and radiation burns.[27]

Secondly, there was less contamination of Japanese land following the Hiroshima and Nagasaki blasts than there was following the Chornobyl release. The bomb explosions thrust the radioactive cloud into the stratosphere, and from there, it was dispersed into a huge volume of water, over the Pacific Ocean. For this reason, Hiroshima and Nagasaki began to be resettled safely within the first two years after the War.[28]

By comparison, on the territories of northern Ukraine and southern Belarus, in an area of 25,000 square kilometers, Chornobyl scattered the equivalent of 100 atomic bombs of radioactive cesium.[29] Health monitors have observed a steady expansion of radionucleides beyond this territory. The greatest concentration of radionucleides is found along the northern banks of the River Pripyat. A large flood could wash a significant volume of radiation into the Dnipro River, and the Dnipro provides drinking water for 35 million residents of Ukraine.

Besides the danger posed by radionucleides suspended in the environment, there is also a need to address the problem of so-called radioactive "hot spots". These are microscopic particles of nuclear fuel, or more often, airborne concentrations of radionucleides. They pose a huge radioactive hazard. Should these particles be deposited in the human organism, the surrounding cells would receive a colossal dose of radioactive exposure. The danger in this exposure lies in the fact that by living over a long period of time in such a hot zone, one can accumulate an extremely large dose of radiation in the lungs and in the lymph glands, creating local hot fields within the body, with doses that exceed 1,000 rads. [30] This is a carcinogenic dose. Over time, malignant

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27 Hachiya, M: "Hiroshima Diary: The Journal of a Japanese Physician -- August 6 - September 30, 1945", Wells, W. (trans and ed.) Chapel Hill, N.C. The University of North Carolina Press (1955)

28 Ibid.

29 "Chernobyl: Symbol of Soviet Failure; 5 Years Later, Scope of Disaster Emerging", Michael Dobbs, Washington Post, No. 142, April 26, 1991. For some isotopes, the Hiroshima equivalent may be substantially higher. See Marples, supra, "to attain the same amount of cesium as produced after Chornobyl, it would be necessary to detonate 750 atomic bombs similar to those dropped on Hiroshima." quoting V. Tokarevskiy, professor of Physics and mathematics at the Ukrainian Academy of Sciences; Radyanska Ukrayina, March 29, 1991)

30 BEIR V Report, supra.

tumors may develop in these hot zones. (See attached chart on tumors in the respiratory system.)

Another disturbing situation which was not addressed by the researchers from the IAEA was the synergistic effect of radiation and other pollutants. The environment of Ukraine has been catastrophically polluted by industrial mutagenic factors stemming from chemical sources. In such industrial cities as Zaporizhia, Dnipropetrovsk, Donetsk, Mariupil, Symferopil, a catastrophic situation has developed which can be compared to Chornobyl. For instance, in Mariupil and in Symferopil, genetic damage from the chemical contaminants is equivalent to an annual exposure to 6 bers of radiation.[31]

The Kiev region is also a major manufacturing center, with extensive chemical pollution. In some villages on the outskirts of Kiev, the level of cadmium exceeds the maximum permissible limit by 10 to 100 fold. There is research underway at the Kiev Medical Institute which indicates a significant increase in the biological effects of low-levels of radiation when combined with heavy metals. (Embryo-toxicity and chromosomal aberrations in particular.)

C. CONCLUSION

In conclusion, we are observing a precipitous decline in the state of health of the Ukrainian population. We need to remember that the IAEA study never examined the health of the highest-risk populations -- namely the 600,000 nuclear clean-up workers and the 200,000 evacuees from the exclusion zone. To make matters worse, health experts do not expect the bulk of the cancers and latent health effects from Chornobyl to occur until ten or fifteen years after initial exposure, when the latency periods for cesium, strontium, and other isotopes have tolled.[32] Under the circumstances of the current economic crisis, Ukraine will need intensive monitoring by health experts for at least the next 20 years, and it will need much more substantial assistance from the United States and other Western nations.

With growing urgency, the Ukrainian Parliament and the Council of Ministers have issued official appeals for aid to Western nations. They have gone out of their way to express their gratitude to those who have already provided aid.

D. RECOMMENDATIONS

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31 Bilayev, S.T.: Demin, V.F.; Knyzhnikov, V. A. "The Concept of minimizing the damage to health and welfare of the population as a result of the Chornobyl accident (Questions and Answers)": Medical Radiology Journal, No. 1, Vol. 37, pp. 20-35 (1992).

32 "Chernobyl: Many children expected to suffer from cancer", USA Today, September 19, 1991. See also Anspaugh, supra, and Davis, supra, who offer conservative ("central") long-term estimates of 17,400 radiation-induced cancers.

1) The U.S. Government should increase and re-distribute medical aid to the Newly Independent States, so that a greater portion flows to the three northernmost provinces of Ukraine (Chernihiv, Kiev, and Zhitomir) which were hardest hit by radiation from Chornobyl.

2) Additional funds need to be appropriated to the Department of Energy, the National Institute of Health, and other agencies for research on radiation health effects, (and funds which have not yet been spent need to be devoted) to the following projects in the Chornobyl region:

a) A long-term health study of the populations which were not examined by the IAEA team, namely, the nuclear clean-up workers and some of the 200,000 evacuees from Chornobyl, who run the highest risk of latent cancers and other health effects. Follow-up studies also need to be done on the general health of people living in regions contaminated by low-level radiation. (Zhitomir Province and the Polissia Region of Kiev Province in particular.) The IAEA team did not have an opportunity to look into the effect of radioactive "hot-spots", and a program needs to be established for the analysis of this problem.

b) Follow-up studies are needed, to determine the extent of chromosome aberrations, and long-term genetic damage among children in Kiev and Polissia, using so-called "biological dossimetry". There is also a need for further investigation of reports of genetic deformations in animals and newborn children.

c) A comparative study of thyroid cancer incidence in children, and assistance in the establishment of a nationwide cancer registry in Ukraine and Belarus.

d) Research on the synergistic effect of radiation and other forms of pollution. Example: a study of the combined effect of exposure to radiation and heavy metals such as cadmium, or a comparison of the health condition of coal miners from the Donetsk Region who were sent to Chornobyl for clean-up duties in 1986, as compared to the health of miners who were never sent to Chornobyl.

e) Assistance for the under-funded Ukrainian Environmental Health Project based at the University of Illinois, which examines the health of mothers and children in Kiev and four other Ukrainian cities.

3) Our government needs to offer incentives to U.S. pharmaceutical firms and hospital supply companies to invest in Ukraine, to help rebuild the country's medical infrastructure, and to benefit from the opening of new markets in this important region.

4) The creation of a scholarship fund for specialists from Ukraine to be trained in the U.S., using American medical equipment and procedures.

5) Help to prevent future Chornobyls by providing engineering technology and technical assistance for the rapid decommissioning of the RBMK-model reactors which continue to pose an ongoing threat to the health and safety of Ukraine and its neighboring countries.[33]

6) The promotion of energy conservation and renewable energy technologies, to help reduce Ukraine's dependency on RBMK reactors and other, environmentally destructive sources of energy such as coal.

7) Encourage cooperation between Ukrainian and American nuclear experts to develop short-term solutions to the contamination hazards posed by RBMK reactors. In particular, we would like to see the Department of Energy explore innovative laser techniques being developed by United Technologies in Connecticut, which would allow nuclear clean-up workers to remedy problems at Chornobyl by remote control, without further exposure to radiation hazards.

The Children of Chornobyl Relief Fund looks forward to working with this Committee toward these ends.

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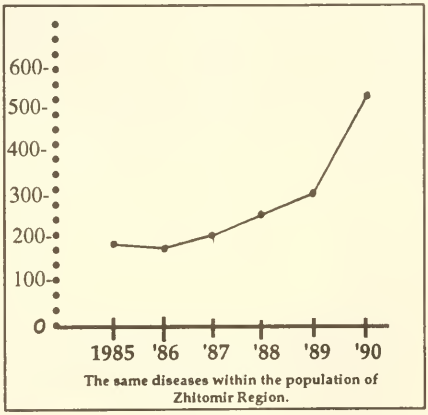
33 Strong, M. "40 Chernobyls Waiting to Happen", New York Times, Op-Ed, Sunday, March 22, 1992.

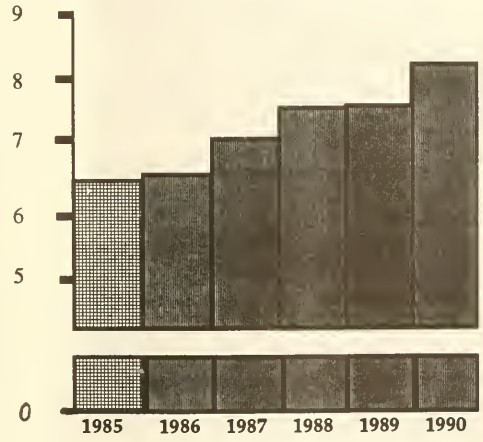
Level of malignant tumors of Lymphatic and Bone Marrow tissues among people throughout Ukraine.

(The number of cases which were newly discovered each year.)

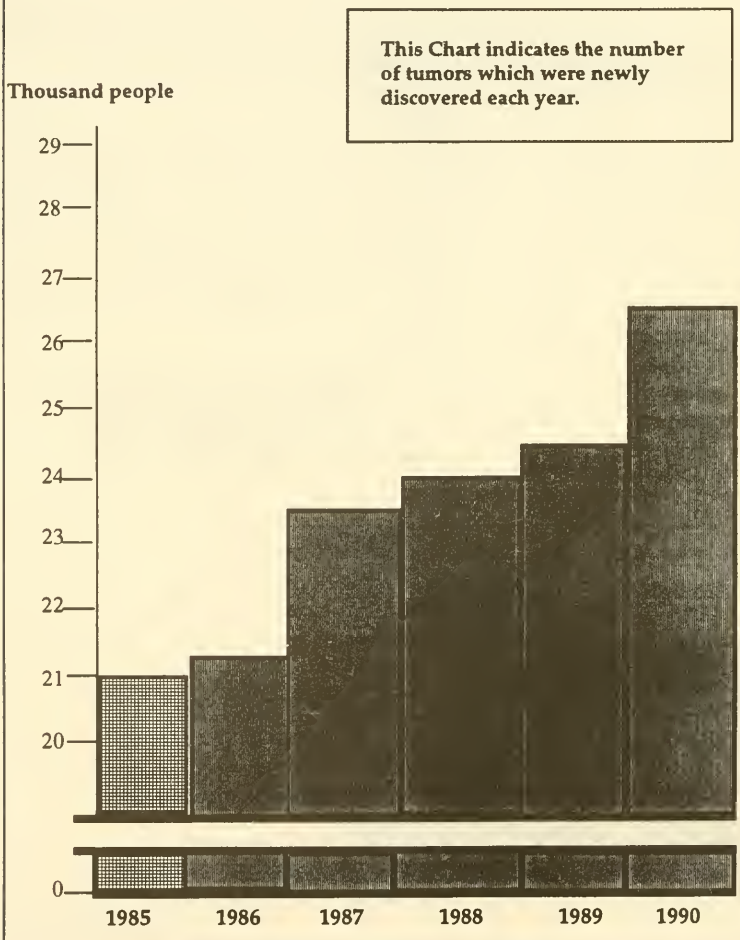


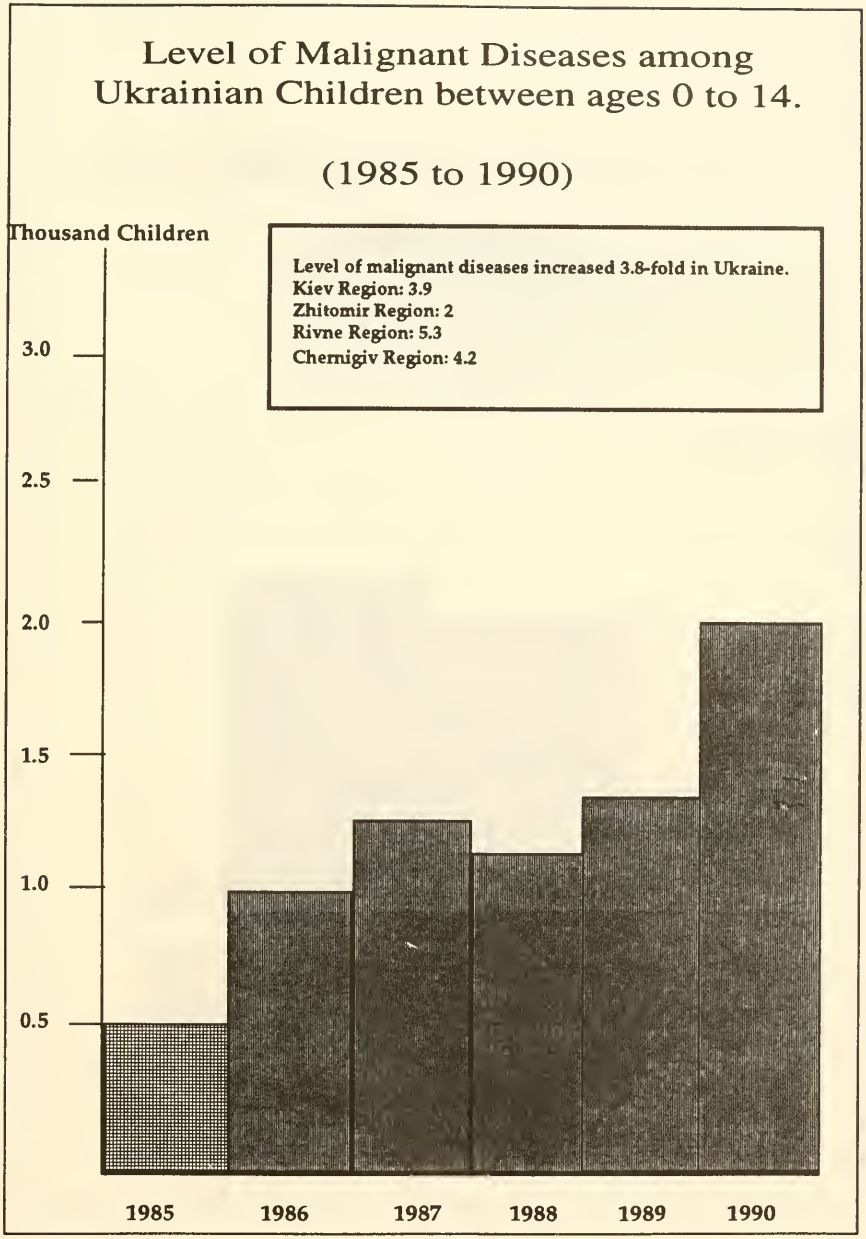
The same diseases within the population of Zhitomir Region.

Thousand people



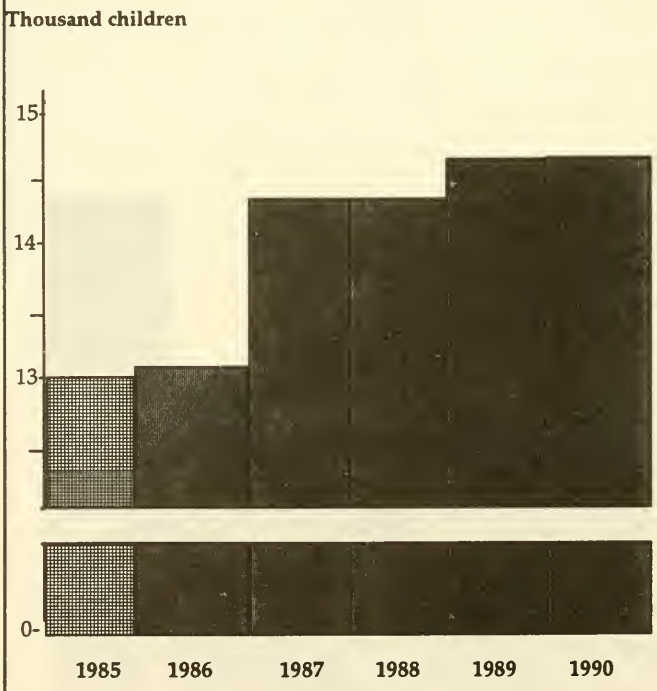
Level of malignant tumors in the Trachia, Bronchus, and Lungs among the people throughout Ukraine.



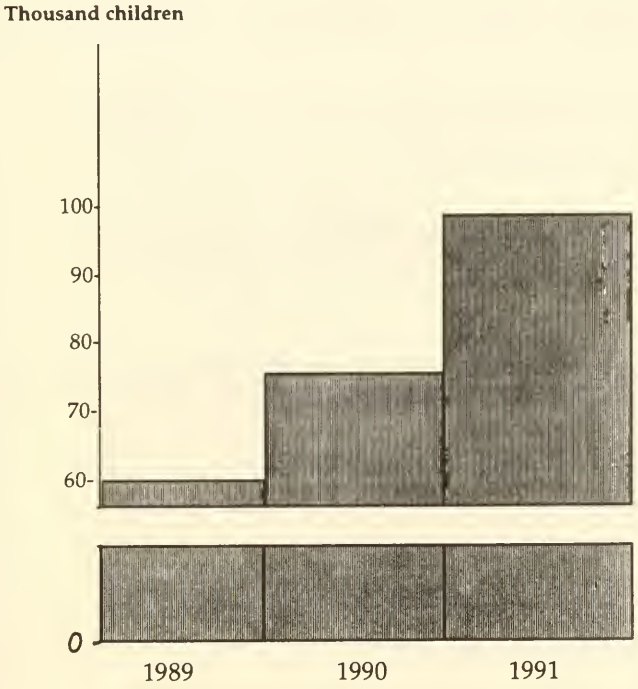

Level of Malignant Diseases among Ukrainian Children between ages 0 to 14.
(1985 to 1990)
Thousand Children
Level of malignant diseases increased 3.8-fold in Ukraine.
Kiev Region: 3.9
Zhitomir Region: 2
Rivne Region: 5.3
Chernigiv Region: 4.2
3.0
2.5
2.0
1.5
1.0
0.5
1985
1986
1987
1988
1989
1990

Number of Newborn with Birth Defects.

(1985-1990)



The Level of non-malignant hematological diseases among Ukrainian Children discovered each year.



INFECTIOUS DISEASES AMONG PEOPLE LIVING IN UKRAINE

A COMPARISON BETWEEN 1990 AND 1985

1) The level of Acute Respiratory Disease in contaminated regions increased **20-fold**.

-- The number of ill children (ages 0-16) increased **2.5-fold** over the adult population.

-- Of all Ukrainians suffering from Acute Respiratory Disease, **65%** are children under the age of 2 years old.

2) There has been a **3-fold** increase in the incidence of tuberculosis among children under the age of 14 years old in the Zhitomir, Volyn, and Rivno regions (in North-Central Ukraine).

The Children of Chornobyl Relief Fund

ACCOMPLISHMENTS
NOVEMBER 1989 -- JUNE 1992

CCRF AIRLIFTS:

- November 1989: Delivered 1,200 lbs. of vitamins and antibiotics to Ukraine with the aid of Parliamentary Deputy V. Yavorivsky.
- February 1990: First official airlift: 85 tons; valued at $2.5 million.
- May 1990: Second Airlift: 124 tons; valued at $4 million.
- June 1990: Third Airlift: 62 tons; valued at $.5 million.
- August 1990: Fourth Airlift: 60 tons, valued at $2.5 million.
- March 1991: Fifth Airlift: 102 tons, valued at $3.2 million.
- November 1991: Sixth Airlift: 74 tons, valued at $2.1 million.
- April 1992: assisted "Thoughts of Faith" organization in airlift of mobile hospitals to Ternopil Region; (procured aircraft, fuel, 3 tons of medical supplies)
- May 1992: Delivered $300,000 of anti-leukemic medicine (oncovin) with I. Drach to Ukrainian Ministry of Health.
- June 1992: Seventh Airlift: 65 tons of medical books, computers, and medicine, valued at $2.0 million.

CCRF - HOSPITALS

- Lviv, Western Ukraine: established a 160-bed Hospital for children with leukemia, Hodgkins Disease, and blood disorders. Full-service hematology laboratory with a full-year supply of reagents. Progress is being made towards the establishment of a Cardiac Surgery Center for children born with curable, congenital heart defects.

- Kiev: co-sponsored Kiev Children's Hospital #14; provided medicine, medical equipment for the Kiev Regional Children's Hospital #1; and the Radiological Dispensary for Chornobyl Problems at Pushcha Vodytsia.

- Kharkiv: established the Children's Medical Center #2 For Chornobyl Problems. (Kharkiv harbors 72,000 evacuees from the Chornobyl region.)

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The Children of Chornobyl Relief Fund

OVERSEAS TREATMENT FOR CHORNOBYL CHILDREN

- CCRF brought 14 Chornobyl children to the United States for medical care.
- CCRF helped to bring 51 children to Israel for cancer treatment.

COOPERATION WITH U.S. & OVERSEAS AGENCIES

- Authorized by the Ukrainian Parliament (Supreme Council) to coordinate all U.S. medical aid to Chornobyl victims in Ukraine.

-Invited to assist in the distribution and oversight of medical aid procured by Project Hope and Abbott Laboratories under the initiative of President Bush, October 1991.

- Aided CITIHOPE international in delivering 70 tons of medical supplies to Minsk, to aid Belarussian children affected by radiation from Chornobyl, November 1991.

- Officially sponsored and coordinated speaking tours for Dr. Yuri Spizhenko, the Ukrainian Minister of Health; Deputy Volodymyr Yavorivsky, Chairman of the Chornobyl Commission; and Dr. Zoreslava Shkiryak-Nizhnik, Director of the Kiev Research Institute of Pediatrics, Obstetrics and Gynecology.

MEDICAL EXCHANGE PROGRAM

-- CCRF developed an exchange program for Ukrainian and American physicians; 106 U.S. physicians to date have travelled to Ukraine to train local doctors in Western medical techniques. Eight Ukrainian health professionals have undergone medical training in the U.S. through internships arranged by CCRF.

PUBLIC EDUCATION CAMPAIGN

--CCRF has presented numerous educational seminars, workshops and briefings in the following cities: Albany, Allentown, Baltimore, Binghamton, Boston, Buffalo, Chicago, Detroit, Flint, Hartford, Hempstead (Long Island), Los Angeles, Minneapolis, New Haven, numerous sites in New Jersey, New York City, Parma (Ohio), Philadelphia, Pittsburgh, Rochester, San Diego, San Francisco, Sarasota, Syracuse, Washington, D.C., Waterbury.

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TESTIMONY

of

Fred A. Mettler, Jr., M.D., M.P.H.

to the

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS -
NUCLEAR REGULATION SUBCOMMITTEEE HEARING

Alan K. Simpson
Ranking Minority Member
Subcommittee on Nuclear Regulation

Bob Graham
Chairman
Subcommittee on Nuclear Regulation

Joseph I. Lieberman
Environment and Public Works Committee

"Effects of the Chernobyl Nuclear Reactor Accident in the Ukraine"

July 22, 1992
Washington, D.C.

FRED A. METTLER, JR., M.D., M.P.H.

Dr. Fred Mettler is currently Professor and Chairman of the Department of Radiology at the University of New Mexico School of Medicine.

He graduated with a B.A. in Mathematics from Columbia University and in 1970 he received an M.D. degree from Thomas Jefferson University. He performed a rotating internship at the University of Chicago and subsequently completed a radiology and nuclear medicine residency at Massachusetts General Hospital. He received a Master's Degree in Public Health from Harvard University in 1975.

Dr. Mettler has authored over 200 scientific publications, including 14 books. He currently is the United States Representative to the United Nations for Radiation Effects and is one of the 13 members of the International Commission on Radiation Protection. He recently was the Health Effects Team Leader of the International Chernobyl Project and also serves as a consultant to the World Health Organization.

He lives in Albuquerque, New Mexico with his wife Gloria and two sons, Erik and Larsen.

The statistics cited in this testimony are excerpts taken from THE INTERNATIONAL CHERNOBYL PROJECT TECHNICAL REPORT, Assessment of Radiological Consequences and Evaluation of Protective Measures, Report by an International Advisory Committee, ISBN 92-0-129191-4, Printed by the IAEA in Vienna, Austria.

Part H

4. Public Health and Possible Clinical Effects of Irradiation

4.1. General Conclusions

At the time of the Project study, there were significant non-radiation-related health disorders in the populations of both surveyed contaminated and surveyed control settlements, but no health disorders that could be attributed directly to radiation exposure. The accident had substantial negative psychological consequences in terms of anxiety and stress due to the continuing and high levels of uncertainty, the occurrence of which extended beyond the contaminated areas of concern. These were compounded by socioeconomic and political changes occurring in the USSR.

The official data that were examined did not indicate a marked increase in the incidence of leukaemia or cancers. However, the data were not detailed enough to exclude the possibility of an increase in the incidence of some tumour types. Reported absorbed thyroid dose estimates in children are such that there may be a statistically detectable increase in the incidence of thyroid tumours in the future.

On the basis of the doses estimated by the Project teams and currently accepted radiation risk estimates, future increases over the natural incidence of cancers or hereditary effects would be difficult to discern, even with large and well designed long term epidemiological studies.

4.2. Detailed Conclusions

4.2.1. Current Health Effects Attributed to Radiation

Reported adverse health effects attributed to radiation were not substantiated either by those local studies that were adequately performed or by the studies under the Project.

Many of the local clinical investigations of health effects had been done poorly, producing confusing, often contradictory results. The reasons for these failures included: lack of well maintained equipment and supplies, poor information through lack of documentation and lack of access to scientific literature; and shortages of well trained specialists. Nevertheless, despite these obstacles, a number of the local clinical studies were carefully and competently performed and the Project teams were to corroborate the results in most cases.

4.2.2. Specific Results of Project Field Studies

Field studies were undertaken of continuous residents of rural surveyed contaminated settlements (with surface contamination higher than 555 kBq m^{-2} (15 Ci km^{-2}) due to caesium) and surveyed control settlements of 2000 to 50 000 persons, using an age matched study design. The studies were performed in the second half of 1990 and relate to the health status at that time. The strategy of the study, to elucidate major health problems identified by general clinical examinations and sophisticated laboratory tests, was adequate to answer most concerns of the population. There was no exhaustive testing of each individual, and the study did not resolve all questions relating to potential health effects.

Psychological Disorders

There were many important psychological problems of anxiety and stress related to the Chernobyl accident and in the areas studied under the Project these were wholly disproportionate to the biological significance of the radioactive contamination. These problems are prevalent even in the surveyed control settlements. The consequences of the accident are inextricably linked with the many socioeconomic and political developments that were occurring in the USSR.

A large proportion of the population had serious concerns, these people were not acting in an irrational way that could be termed radiophobic. The vast majority of adults examined in both the surveyed contaminated settlements and the surveyed control settlements visited either believed or suspected that they had an illness due to radiation. Most adults in both surveyed contaminated and surveyed control settlements were native to the local area and virtually all stated that they had lived in the settlements since birth, therefore relocation is a major concern. While only about 8% of adults in surveyed control settlements wanted to relocate, the adults in the surveyed contaminated settlements were so concerned that 72% wanted to relocate. The percentages of the population who thought that the Government should relocate the whole population were higher: 20% and 83%, respectively.

General Health

The children who were examined were found to be generally healthy. Field studies indicated that a significant number of adults in both surveyed contaminated and

surveyed control settlements had substantial medical problems, with 10% to 15% (excluding hypertensive adults) requiring medical care.

Cardiovascular Disorders

Many adults were hypertensive; however, the statistics related to both systolic and diastolic blood pressure were similar for both surveyed contaminated and surveyed control settlements, and both were comparable with published values for Moscow and Leningrad.

Nutrition

Diet appeared to be limited in range but adequate. No significant differences in reported eating habits were found between surveyed contaminated and surveyed control settlements. No detrimental effects on growth due to voluntary or official dietary restrictions imposed as a result of the accident were found. There were no significant differences between the growth rates of children in surveyed contaminated and surveyed control settlements, and the rates for both groups were well within published USSR and international norms. Adults were generally overweight by international standards in all areas studied. Intake and excretion of iodine were found to be at the low end of the acceptable range. Most other dietary constituents and components were found to be adequate, however. Vitamin intake was not examined. Dietary intakes of toxic elements (lead, cadmium and mercury) were low in comparison with those reported for many other countries and were well below the maximum tolerable intake levels specified by international organizations. Blood lead levels were also investigated and were found to be well within the normal range.

Thyroid Gland Disorders

No abnormalities in either thyroid stimulating hormone (TSH) or thyroid hormone (free T4) were found in children examined. No statistically significant difference was found between surveyed contaminated and surveyed control settlements for any age group.

Mean thyroid sizes and size distributions were the same for populations of surveyed contaminated and surveyed control settlements. Thyroid nodules were extremely rare in children, they occurred in up to 15% of adults in both surveyed contaminated and surveyed control settlements. Project results are similar to those reported for populations in other countries.

Haematology

Some young children with low haemoglobin levels and low red cell counts were identified. However, there was no statistically significant difference between values in surveyed contaminated and surveyed control settlements for any age group of the population. No difference was found between the populations when leucocytes and platelets were examined. Immune systems (as judged from the lymphocyte level and the prevalence of other diseases) did not appear to have been significantly affected by the accident.

Neoplasms

Review of Soviet data indicated that reported cancer incidence had been rising for the last decade (starting before the Chernobyl accident occurred) and has continued to rise at the same rate since the accident. The Project teams considered that there had been incomplete reporting in the past and could not assess whether the rise was due to increased incidence, methodological differences, better detection and diagnosis or other causes. The data did not reveal a marked increase in the incidence of leukaemia or thyroid tumours since the accident. However, owing to the classification scheme used and other factors, the possibility of a slight increase in the incidence of these tumours cannot be excluded. Only hearsay information relating to such tumours was available.

Radiation Induced Cataracts

There was no evidence of radiation induced cataracts in the general population.

Biological Dosimetry

Chromosomal and somatic cell mutation assays were performed on adults who had worked outdoors, selected since their exposures were assumed to be the highest. No significant difference were found between adults living in surveyed contaminated and surveyed control settlements. The data obtained were consistent with the Project dose estimates.

Foetal and Genetic Anomalies

Review of Soviet data for settlements in contaminated areas of concern as well as for the three Republics as a whole indicated relatively high infant and perinatal mortality levels. These levels prevailed before the accident and appear to be decreasing. No statistically significant

evidence was found of an increase in the incidence of foetal anomalies as a result of radiation exposure

4.2.3. Potential Delayed Health Effects

Available data reviewed did not provide an adequate basis for determining whether there had been an increase in leukaemia or thyroid cancers as a consequence of the accident. The data were not detailed enough to exclude the possibility of an increase in the incidence of some tumour types. On the basis of the doses estimated by the Project teams and currently accepted radiation risk estimates, future increases over the natural incidence of all cancers or hereditary effects would be difficult to discern even with large and well designed long term epidemiological studies. Reported estimates of absorbed thyroid dose in children are such that there may be a statistically detectable increase in the incidence of thyroid tumours in the future.

4.3. Recommendations

4.3.1. General Health and Potential Accident Consequences

The adverse health consequences of relocation should be considered before any further relocation takes place.

Consideration should be given to the introduction of programmes to alleviate psychological effects. These might include informational programmes for the public. There should also be educational programmes set up for teachers and local physicians in general preventive health care and radiation health effects.

The current policy of annual physical examinations is conceptually adequate for the health needs of the general population in the contaminated areas of concern. However, certain high risk groups (such as children with high absorbed thyroid doses) will need specific medical programmes based on their potential risks.

Energetic action should be taken to improve the standard of medical, diagnostic and research equipment and the availability of medical supplies, manuals and spare parts.

Clinical and research investigations should emphasize the use of appropriate control groups, standards and quality control procedures.

Improvements should be made in the statistical, data collection and registry systems used by local scientists by the adoption and application of internationally accepted standards and methods.

There should be increased opportunities for information exchange and greater availability of scientific literature for local health professionals.

4.3.2. Potential Delayed Health Effects

In view of the limited resources available, the concept of the WHO Scientific Advisory Group on the Health Effects of Chernobyl, namely to concentrate on prospective cohort studies of selected high risk populations, should be endorsed. It is impractical, owing to the extreme difficulty and cost, to conduct long term studies or to evaluate all persons who live in the affected Republics.

4.3.3. General Public Health Issues in the Affected Republics

Action should be taken on adult hypertension and dental hygiene as major health issues. The need for continuing programmes for iodization of salt should be re-evaluated, if these are found to be necessary, the effectiveness of the chemical process should be assessed.

Full Tables attached to this statement have been retained in committee files.

There remain very large areas of the Soviet Union which have contamination levels in the range of or exceeding 15 Ci/km^2 (555 kBq/m^2) of ^{137}Cs. Some of these areas are located as far as 300 km from the plant.

The accident and contaminated areas include three administratively distinct areas of the UkrSSR, BSSR and RSFSR. Populations still living in contaminated areas are probably in excess of half a million with at least 60 000 children still living in these areas.

In terms of review and correlation of the Soviet health effects data, it was apparent that there were major differences in the scientific and medical backgrounds, purposes and capability, not only between the Project Task 4 teams and their Soviet counterparts but also within the Soviet structure itself. It was a credit to the Soviet people that we could work together in an effort to achieve a common goal in terms of assessment of the health effects of Chernobyl.

Correlation and corroboration of the Soviet data internally and with our data were difficult for several reasons. One reason, which was obvious to all involved in the project, was that our Soviet colleagues most often did not have access to technology which is considered quite commonplace in medical diagnosis and practice in many western countries. In some of the institutes and very large hospitals, modern equipment was present but the equipment even in these often was not operating because of the lack of chemical reagents or minor spare parts.

A second problem was more difficult. Many of the Soviet health related studies were performed by well intentioned persons who did not have a firm foundation in the design of scientific experiments and the value of consistent methodology and controls. There were many contradictions in data that were presented to us. While there were some first rate investigations these were in the minority. A number of scientists and physicians appeared to have limited and narrow backgrounds which caused them to make assumptions and conclusions which did not logically follow on a scientific basis. As a result, many of the studies were internally contradictory and assumptions were presented as facts without the benefit of critical review and examination of the studies for biases and design flaws.

While there are published uniform methodologies for follow-up of certain persons affected by the accident, these procedures are rarely, if ever, followed. One reason for this is that the equipment and reagents needed to follow the guidelines are simply not available. Another reason is that the various investigators wish to be independent. Unfortunately, this leads to data that are inconsistent and cannot therefore be compared from Republic to Republic or in some instances between different institutes in the same city.

A third problem was the result of recent acquisition of some modern pieces of equipment by Soviet scientists without the benefit of the necessary support foundation related to useful and accurate operation of the instruments. Calibrating standards were usually not available nor were operating manuals in Russian.

A fourth major problem was the lack of literature for the instrument operators and those scientists and physicians who were designing studies. Some of the studies were aimed at goals which have already been studied extensively in other countries and the negative results of which are already widely published in the open literature. In some cases there seemed to be unrealistic optimism that new technology could provide answers to almost any problem and that the results were automatically correct. The technical and interpretative limitations of medical diagnostic equipment were sometimes not well understood.

In spite of all the above limitations, we were able to correlate a substantial amount of data from a number of Soviet studies. Most of the Soviet studies in which we were able to confirm findings were performed on equipment that was somewhat outdated but which the Soviet scientists understood very well. In other areas (such as tumour incidence data) we were only able to review data and provide comments, but we were not able to verify the data since we could not repeat or successfully sample such large populations in the time we had or with the resources we had. In addition, many of the data had been obtained in past years and the only method of verification that could have been used was a labour intensive process of extensive record and pathology review. It should be clear that our findings pertain only to those persons living in rural areas within 300 km or so of Chernobyl. They do not apply to the decontamination workers, Chernobyl plant operators or persons already relocated. We did have a chance to examine some of the workers and firemen initially severely injured in the accident and we were very impressed with their medical care and outcomes; we did not, however, collect data in this regard.

It should also be clear that these results only represent the state of health during the fall of 1990. We cannot speak of health effects in the period before 1990 except through knowledge of the scientific basis of radiation health effects and what is currently found. Our disease detection process and study was limited to certain specific problem areas and a general physical examination. Even though we detected a significant percentage of people with major health problems requiring medical care, supervision or treatment, it is certain that there were additional abnormalities in the population that could only have been detected with additional tests. Our study is only one set of data points in the investigation of a very large problem. It is certain that there are facets of the accident which need further investigation in the future.

Our review and analysis indicated major health problems in several areas. With some qualifications, there were no direct effects that we were able to confirm as being directly attributable to radiation effects at this time. There are clearly some effects, most notably psychological, which are felt to be the direct result of the accident. Potential future effects such as cancers are considered in Part II (Conclusions and Recommendations).

TESTIMONY OF
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BEFORE THE

SUBCOMMITTEE ON NUCLEAR SAFETY
SENATE COMMITTEE ON THE ENVIRONMENT AND PUBLIC WORKS
JULY 22ND OF 1992

I wish to thank this Committee for the opportunity to testify about health matters that relate to the Chornobyl tragedy, the current medical circumstances in Ukraine and the need for U.S. assistance.

INTRODUCTION

In August 1991, Ukraine declared independence after centuries of subjugation by the former Russian-USSR empire. Four months later, support for independence was asserted by over 90% of the Ukrainian and non-Ukrainian voters, the largest plurality in the recorded history of free elections. Ukraine has been lacerated by the Chornobyl tragedy.

One consequence of Ukrainian independence was the abrupt loss of medical support formerly stemming from Moscow. Another consequence is that Ukraine has now virtually no representation in key international bodies, such as the World Health Organization where many crucial decisions about Chornobyl continue to be made. Also, Ukraine has no foreign currency reserves. Ukrainian authorities recognize that they can not cope with the Chornobyl consequences and have called for international assistance.

QUALIFICATIONS and VIEWS

Describing my qualifications is relevant because they are similar to those of other members of the "American-Ukrainian Medical Sciences Group" that I represent. In fact, our life stories are similar to those of many other Ukrainians in the U.S. We are viewed in Ukraine as exponents of those that were given opportunities in America; we worked, achieved and were rewarded. The equation for America includes: hope - opportunity - work - success, and is completed by concern and generosity for those in need.

In 1946, my family and I received assistance from the U.N. Refugee Administration to leave Europe and travel to Argentina. Fourteen years later, I earned my medical degree but not without the generous help of various scholarships. After thirty years, I will soon have the honor to accept a nomination to become a member of the Argentine Academy of Medicine. My acceptance address will be about Cancer, Birth Defects, Public Health and Chornobyl. Chornobyl has universal implications.

In 1962, I arrived in the U.S. with one hundred dollars and minimal knowledge of English. I received training in pediatrics at Washington University and the Saint Louis Children's Hospital. Five years later, I completed my training in Medical Genetics at the Harvard School of Medicine and the Boston Children's Hospital. I became a citizen, was drafted and served as Senior Surgeon of the Public Health Service at the Epidemiology Branch of the National Cancer Institute, in Bethesda, Maryland. Twelve years after landing in the U. S., I became the Chairman of a new Department of Medical Genetics in the College of Medicine of the University of South Alabama, in Mobile, Alabama.

For twenty years I have endeavored to prevent birth defects and mental retardation. I know first hand how important it is to harmonize the relationships between scientific research, clinical services and public

education. The same comprehensive and coordinated approach is needed to address the consequences of Chornobyl.

Radioactivity is the best known example of an agent that induces cancer, gene mutations, chromosome defects, birth defects and mental retardation. Radiation damage extends beyond single victims; it afflicts families, communities, populations and future generations. The Chornobyl tragedy cannot be viewed through few narrow scientific windows; such approach dehumanizes the complexity of this disaster.

While science is essential to find and propagate truth, sciences in medicine must be complemented by clinical wisdom if healing and amelioration are to be achieved. It is self-evident that science alone cannot alter perceptions, attitudes, and behaviors which are complex matters.

I am deeply concerned that Chornobyl is increasingly perceived as an example of a failure of industrialized nations to help those whose tragedy is underserved. Some politicians find in Chornobyl an example why western democracies need not be emulated. For six years there have been debates about helping Ukraine with modest consequences.

I firmly believe that assistance is warranted and that America will show others the leadership and humanism that justifies our high standing among other nations.

I believe that Chornobyl calls for broad and JOINT solutions by U.S.-Ukrainian scientists and clinicians. Of equal importance is the need to involve the Ukrainian public, families and communities in the broadest sense of these words. General trust is essential. Our experience in the Gulf Coast region demonstrates that "each one - teach one" is one ingredient that unites scientists and humanists under the most adverse socio-economic circumstances. We employ a school teacher, a former diplomat and other community leaders who succeed in erasing a "provider - recipient" mentality. Such mentality is irrelevant in the case of birth defects or radiation effects.

In summary, the Chornobyl accident imposes upon the international scientific community not a choice but a moral obligation to learn about its consequences.

THE "AMERICAN-UKRAINIAN MEDICAL SCIENCES GROUP"

Our group brings together medical investigators and clinicians who hold appointments in universities, teaching hospitals and scientific centers. Among us are members of the National Academy of Sciences, chairmen of academic departments, experts in genetics, radiology, biophysics, pediatrics, obstetrics and other specialties. Many of us have considerable teaching and administrative experience. Our group has developed linkages with hundreds of U.S and Ukrainian scientists and physicians interested in Chornobyl and in bilateral participation through joint projects.

We can state unambiguously that there is a sufficient number of qualified and interested professionals in the U.S. and Ukraine to sustain ambitious, comprehensive, coordinated and long-term bilateral projects. Secondly, we

also are certain that various academies, foundations and charitable organizations will join in our efforts.

CHORNOBYL: SCIENCE AND ASSISTANCE

The most publicized document about Chornobyl, rather badly received in Ukraine, is a 1991 report by an International Advisory Committee requested by the USSR. The study had self-admitted limitations:

- The project was not intended to have either the rigor or the comprehensiveness of an elaborate long term research study.

- The number of available independent experts and their time were limited.

- The data provided by the USSR was not always adequate nor could there be an independent assessment of the radiological events at the time of the accident.

- Numerous 'hot spots' of exceptionally high surface radioactivity have not been singled out for investigation.

- Evidently, investigation of chromosomal abnormalities was not possible.

To add further perspective I would also point out that:

- The Chornobyl accident is the largest release of radioactive materials ever recorded. Within the first week after the accident of April 26th, 1986, 90,000 children were evacuated. The International Advisory Committee ascertained that an astounding 72% of individuals in contaminated settlements wanted to be relocated. The percentages of the population who thought that the government should relocate the whole population are even higher. Thousand of children and unborn were exposed to unknown levels of radiation.

- In addition to Chornobyl, deteriorating economic circumstances have created a global medical crisis. Recurring diphtheria epidemics can no longer be ignored.

- There are growing demands to "ship" Ukrainian children for treatment abroad. A growing number of Ukrainians feel that such trends do not address the fundamental problems of the medical needs of Ukrainian children.

- The "sarcophagus" and damaged atomic reactor will require considerable international efforts to dismantle this threat.

- It will become unacceptable to sustain nuclear safety projects without a parallel and equally credible attention to medical programs.

- America cannot afford to be perceived as an technological giant indifferent to human values. It is our record on human values that lends America its stature among nations.

- Should epidemics and other medical disasters emerge in Ukraine, solutions will be less effective and more onerous, both financially and politically.

- The considerable U.S. investment in studies of Hiroshima-Nagasaki is one of the most successful long-term scientific commitments ever made. Chornobyl deserves equal consideration.

CONCERNING COORDINATION AND EFFECTIVENESS OF U.S. MEDICAL AID

Money alone does not solve problems; people do. Organizations such our "American-Ukrainian Medical Sciences Group" may facilitate linkages between American and Ukrainian medical scientists. Other Ukrainian organizations, academic and charitable, have also first hand experience and have established bilateral linkages with Ukraine. A framework is already in place to facilitate the flow of assistance through established and experienced networks. American-Ukrainian organizations provide substantial non-governmental assistance to Ukraine. These organizations are nurtured by millions of American-Ukrainians.

I believe that the effectiveness of medical aid also depends on careful planning. It is self-evident that the strong contrasts between the former USSR and our systems in addition to language barriers must be addressed. A key role of our "American-Ukrainian Medical Sciences Group" is to expedite the formation of bilateral planning, coordination, and supervisory teams and to provide consultants to "pave the way".

GOALS AND OBJECTIVES FOR U.S. MEDICAL AID

The purpose of U.S. aid should be to investigate, cure or ameliorate the effects of the Chornobyl disaster and to instill public trust in U.S. medical and scientific institutions.

The major goals for assistance can be grouped into two domains:

- Programs of immediate medical assistance.
- Creation of an AMERICAN-UKRAINIAN MEDICAL SCIENCES CENTER to include a CHORNOBYL INFORMATION CENTER AND DATA REPOSITORY.

We endorse the recommendations made by the International Advisory Committee and add our own (in parenthesis):

- "Energetic action should be taken to improve the standard of medical diagnostic and research equipment and the availability of medical supplies ..."

- Specific medical programs for children, based on their potential risks for thyroid cancer. (We focus on this issue in some detail below.)

- (Assessment of genetic effects and chromosomal abnormalities.)

- Programs to alleviate psychological effects.

- Develop programs with emphasis on high risk populations, particularly those exposed to "hot spots".

- (Develop Programs to provide:
  Public Information.
  Incentives for joint ventures to develop a pharmaceutical industry.
  Incentives for businesses to engage in joint ventures in medical technology and issues related to the food chain.)

About Medical Supplies

There is an acute need for childhood immunization, basic supplies of syringes and needles, diagnostic equipment, etc.

About Thyroid, Leukemia and Other Cancers

The International Advisory Committee stated that "available data reviewed do not provide an adequate basis for determining whether there has been an increase in leukemia and thyroid cancer as a consequence of the accident". We believe that this should be established.

Concerning thyroid cancer, there is an immediate need to establish a surveillence program. It is estimated that 800,000 children may be at risk. Thyroid disease is asymptomatic. Studies of children exposed to radiation fallout have shown that only 3% knew of their disease prior to a careful thyroid examination. A recent review from the Brookhaven National Laboratory pointed that "more data are needed on low-dose effects of radioiodines on the thyroid ... in view of the preponderance of thyroid abnormalities ... in children ... (the unborn) ... further data would be desirable ... in children and human fetuses". Another review stated "it is clearly important to attempt to define subgroups of the population who may be extra-sensitive to the effects of radiation to the thyroid gland." The fetal thyroid is avid for iodine and takes up iodine by the 10th week. In Ukraine, it is not known how many unborn and young children were exposed to radioactive iodine. It is known that the Chornobyl environs are poor in iodine which poses an additional risk factor for this population. Purely epidemiologic studies of risks and outcomes are humanistically unacceptable. Investigations have to include medical monitoring, health care and prevention.

The global problem posed by Chornobyl is further illustrated by the fact that in France, calf thyroids were taken "off market" by May 10, 1986. Thyroids of sheep in Scotland reached hundreds of times greater level of radiation than those in France. In Vermont, the atomic cloud resulted in the highest reading of radioactive iodine ever recorded in the continental U.S. (May 11th).

There are growing reports of increasing incidence in Ukraine of childhood thyroid cancer and leukemia. The long term cancer risks from the received and on-going chronic low dose radiation are not known.

About Psychological Effects

Massive psychological effects following disasters is well documented. In the U.S., following the 1972 Buffalo Creek Dam disaster that killed 125 people, 80% of the population was found to be emotionally disturbed and be afflicted by what psychiatrists called the "Buffalo Creek syndrome". It is self-evident that the trauma of Chornobyl is enormous.

The public is aware that radiation is a cause of microcephaly, mental retardation, cataracts, thryoid cancer, leukemia, bone cancer, birth defects, gene mutations, chromosomal aberrations and decrease life span. In distant Italy rigorous studies showed a sharp increase in induced abortions following Chornobyl.

To what extent Chornobyl will result in an increase in mental retardation, microcephaly, cataracts and other complications remains to be seen.

About Genes and Chromosomal Aberrations

Chromosome aberrations can be induced by relatively low doses of radiation. A rigorous German study of German workers that were in the general vicinity of Chornobyl showed a significant increase of major chromosome aberrations. I am unaware of rigorous chromosomal studies on populations from Ukraine.

About High Risk Populations

The International Advisory Committee recognized that there were numerous "hot spots" of exceptional high surface radioactivity and that these were not singled out for investigation. We agree with the recommendations of this Committee to develop "programs with emphasis on high risk populations, particularly those exposed to "hot spots". Evacuees from Chornobyl, clean-up workers, firemen, and other participants in Chornobyl works require special attention.

About Public Information Programs

These should be initiated as soon as possible and reflect the contributions of U.S. sources.

About Incentives for Joint Ventures
(Pharmaceuticals, Medical Engineering, Food Chain, Etc.)

The development of a pharmaceutical industry (particularly vaccines) is acutely needed.

Basic scientists, formerly employed in military projects, can provide an important human resource to establish a medical technology base and deal with issues related to the food chain.

AMERICAN-UKRAINIAN MEDICAL SCIENCES CENTER

The creation of an AMERICAN-UKRAINIAN MEDICAL SCIENCES CENTER will provide a stable long term "platform" for rapid and effective introduction of technology along with clinical "know-how".

The process can be initiated promptly by the establishment of "Centers of Excellence", which will function as independent non-governmental medical and research facilities, under joint U.S. and Ukrainian control and subject to U.S. standards. Each "Center" will promote, facilitate, and provide a stable "home base" for U.S.-Ukrainian research and medical care teams. The Centers would be eventually amalgamated into an "AMERICAN-UKRAINIAN MEDICAL SCIENCES CENTER". An interim step could be an amalgamation of "Centers" into an "AMERICAN-UKRAINIAN CHILDREN'S CENTER".

The urgency of the medical circumstances in Ukraine call for the immediate development of two "CENTERS":

American-Ukrainian Cancer-Leukemia Center
American-Ukrainian Terato-Genetics Center

CHORNOBYL INFORMATION CENTER AND DATA REPOSITORY

As a major component of a proposed "American-Ukrainian Medical Sciences Center", the Information-Data Repository Center would serve the need to create and coordinate regional and national registries of disease incidence, tracking and monitoring of interventions, coordinating and promoting international interactions among medical scientists, participating in public information and professional education, promoting informatics and computer technology, etc.

Much of the aid reaching Ukraine thus far is mostly from American-Ukrainians and local business communities. The plan to develop "Centers of Excellence" aims to provide incentives for participation by businesses and non-governmental organizations. These "Centers" will inherently become "showcases" of American technology and "know-how". An AMERICAN CHILDREN'S HOSPITAL and later an AMERICAN MEDICAL SCIENCES CENTER, will provide high quality medical care, subjected to U.S. standards and be open to patients beyond Ukraine. The impact of such medical facility on Eastern Europe is likely to be substantial. We ask that the committee endorse our plans and seek funding to propel implementations. We have indications that the Ukrainian authorities are prepared to delegate hospital and laboratory facilities or otherwise would welcome the construction of new facilities.

CONCLUSION

Substantial aid to Ukraine is warranted on humanitarian, scientific and geo-political grounds. The U.S. has heavily invested in the investigations of Hiroshima-Nagasaki. A similar investment is needed to study and ameliorate the effects of Chornobyl. An AMERICAN-UKRAINIAN MEDICAL CENTER is an effective way to provide for the integration of complex long term research, medical care and public information projects. It is also a highly visible contribution that will demonstrate the creative U.S. role in a highly sensitive area. Furthermore, a helping hand from America is an effective way to promote our own democracy. The fate of the emerging democracy in Ukraine will have profound future implications. The aid provided to Ukraine has been, thus far, primarily non-governmental. The American-Ukrainian community has created linkages that provide conduits for effective aid and accountability. Millions of American-Ukrainians are now seeking from our Government leadership and support.

American-Ukrainian Medical Sciences Group

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Wladimir Werteleckyj, M.D., Professor and Chairman
Dept. of Medical Genetics, CC/CB 214
University of South Alabama - Mobile, AL USA 36688

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August 26, 1992

Senator Alan K. Simpson
United States Senator
Committee on Environment and
Public Works
Washington, D.C. 205 10-6175

Dear Senator Simpson:

Thank you for your letter of July 28th. I just returned from a field trip to Ukraine which is the cause for the delay of my answer. I wish to thank you for your interest in issues relating to Chornobyl, Ukraine and medical-humanitarian assistance. My trip during which I met scores of Ukrainian leaders has lent further support to the opinions I expressed during my deposition of July 22nd.

I attach to this letter my answers to your questions. In addition, I attach letters of support from highly placed Ukrainian leaders. I am gratified that so many distinguished colleagues in Ukraine agreed to support the statements that I made to the U.S. Senate on July 22, 1992. I respectfully request that these documents be added to the record.

I take this opportunity to extend to you my personal thanks.

Sincerely yours,

W Werteleckyj

Wladimir Werteleckyj, M.D.
Coordinator, Professor and Chairman

WW/swb
Attachments

Attachment 1
Re: Question 1

What is the "synergenetic" investigation whose results have never been released which you referred to in your oral testimony? What were the findings and the importance?

I regret that I could not find exactly the statement alluded to. However, I believe that the question stems from my views about the "synergistic" effects of global financial assistance rather than the limited effects that purely scientific, health care or humanitarian assistance achieve if rendered separately. This point deserves elaboration because it relates to the letters of support concerning my previous deposition to the U.S. Senate.

It is self-evident that in Ukraine there is an abundance of highly qualified scientists and professionals. There is also broad recognition that existing Ukrainian administrative structures reflect the failures of the "centralized planning" characteristic of the former USSR. As shown in the letters of support (Attachment 2), there is broad agreement that new structures need to arise. Specifically, the possibility of creating AMERICAN-UKRAINIAN MEDICAL SCIENCES CENTERS, to provide stable long term "platforms" for rapid and effective introduction of American "know how" was warmly received. As such "centers" grow in number, the idea of amalgamating the "centers" into an "AMERICAN-UKRAINIAN CHILDREN'S CENTER(S)" was also enthusiastically received. Achieving such goal would be a monument to U.S. solidarity, to the emerging democracy of Ukraine and to the victims of Chornobyl.

Each "center" would pursue limited and well defined goals. Specific "American-Ukrainian Task Forces" would seek to "synergistically" address issues of education, training, health delivery and research in well defined medical domains. For instance, in Ukraine there are scientific reasons to expect a growing number of individuals exposed to the radioactivity from the Chornobyl fallout to develop leukemia. An "AMERICAN-UKRAINIAN CANCER-LEUKEMIA CENTER(S)" can be developed rapidly with relatively modest financial resources (about 25% of the equivalent cost in the U.S.). It must be underscored that a large proportion of such expenditures would be for the support of U.S. scientists, U.S. suppliers and other U.S. participants. In fact, I estimate that less than 50% of such assistance would be for expenditures in Ukraine.

Currently, the causes of leukemia remain unknown. There are strong scientific reasons to believe that radiation induced leukemia may reflect different molecular alterations than "sporadic" leukemia. This view is supported by the most eminent U.S. cytogeneticists. These highly respected scientists strongly believe that there is an urgent call to initiate immediately such investigations. There are no other human populations that can be studied to answer such questions. The potential discoveries may have tremendous scientific and economic implications. However, because of the rapidly deteriorating social and medical

circumstances in Ukraine, there is a growing trend for those that can to send their leukemic children for treatment abroad (a source of strong social resentments by those who cannot afford such alternative). Medical investigations concerning leukemia without concurrent health care delivery assistance are not feasible.

The above is an illustration of a "synergistic" investment to achieve academic, administrative, social, clinical and scientific goals. In addition to "CANCER-LEUKEMIA", other "centers" could focus on issues such as "birth defects", "maternal child health", etc. Each "center" is an ideal platform for U.S. academic as well as private organizations to demonstrate our know how and promote our technology. The "centers" can also provide a platform to diminish the impact of competing technologies being introduced by nearby european industrialized nations to this important region of 50 million people.

Re: Question 2

You recommend utilizing existing frameworks, organizations and bilateral relationships between Ukrainians and Americans to facilitate assistance. Do you have a specific program in mind and the requirements for U.S. government participation or funding?

To achieve the implementation of complex medical programs we recommend the formation of goal oriented TASK FORCES. Our American-Ukrainian Medical Sciences Group can expedite the formation of TASK FORCES because we represent a cross section of medical disciplines and have broad linkages with American scientific community. Each TASK FORCE would "synergistically" address issues of education, training, administration, technology, research and medical care delivery in well defined domains of medical sciences. Each TASK FORCE would be composed by U.S., Ukrainian as well as American-Ukrainian specialists. In addition to defining goals and objectives, each TASK FORCE would seek to develop new physical and administrative structures referred here as "centers". As shown in the letters of support, there is clear enthusiasm for such an approach. Ukrainian physicians and scientists abroad and in Ukraine strongly support such a strategy (Attachment 2).

Of important relevance is the need to develop an "AMERICAN-UKRAINIAN CANCER-LEUKEMIA CENTER(S)". With proper financial support, our organization is in a position to develop a TASK FORCE within 60 days to be composed of outstanding U.S. scientists, clinicians and other specialists along with counterparts in Ukraine. I am confident, on the basis of personal knowledge in the U.S. and Ukraine, that a functioning "center" could be developed in the relatively short span of about one year. On the other hand, I also unfortunately believe that funding separately scientific, health delivery, and humanitarian projects through financial aid through existing administrative structures in the U.S. directed at existing Ukrainian organizations will achieve at best limited results.

The U.S. Government has already recognized the importance of creating partnerships between individual scientists as reflected in programs sponsored by the National Science Foundation and National Institutes of Health. In the case of complex medical problems such as leukemia, birth defects and biologic consequences of Chornobyl, specific TASK FORCES to include U.S., U.S.-Ukrainian, and Ukrainian counterparts are necessary. TASK FORCES, in addition to define goals and objectives and channel financial assistance but must insure the creation of new physical facilities, referred here as "centers", where U.S. style of administration and problem solving could be implemented.

Державна дума України

Колегія з питань гуманітарної політики

252008, Київ-8, вул. Михайла Грушевського, 12/2 тел. 293 39 34

"17" 08 1992 р. № 10/154

Professor Wolodymyr Wertelecki
Chairman, Department of Medical
Genetics University of South Alabama
Coordinator, American - Ukrainian
Medical Sciences Group

Dear Sir:

We have studied your deposition to the US Senate concerning the Chernobyl disaster.

On behalf of the State Council of Ukraine(Duma) whose functions include to coordination of the roles of various Ministers to achieve a cohesive policy for Ukraine, it is with pleasure that we support the contents of your deposition.

Furthermore, we welcome any furher assistance you may render the US Senate or other agencies that may help Ukraine which faces great difficulties.

We hope that you may promote and achieve a greater degree of coordination in the efforts of those that may seek assistance to Ukraine.

With best regards

National Adviser
of Ukraine M. Zhulynsky

UKRAINIAN MEDICAL ASSOCIATION OF NORTH AMERICA
NATIONAL OFFICE

УКРАЇНСЬКЕ ЛІКАРСЬКЕ ТОВАРИСТВО ПІВНІЧНОЇ АМЕРИКИ
ГОЛОВНА УПРАВА

TEL: (312) 278-6262 • 2247 W. CHICAGO AVENUE CHICAGO, ILLINOIS 60622 • FAX: (312) 278-6962

W. Wertelecki, M.D.
Chairman, Dept. of Medical Genetics
University of South Alabama
Mobile, Alabama 36688

Dear Dr. W. Wertelecki:

On behalf of the Ukrainian Medical Association of North America, I wish to extend this letter of support concerning your depositions to the U.S. Senate.

We studied your depositions and are glad to concur with your views about the urgent need for humanitarian and medical assistance to Ukraine. The issues emerging from the Chornobyl tragedy are universal and deserving of International support. The United States is a country that not only stands as a technological giant but is also a bastion of humanism.

We hope that the U.S. Senate will render help to Ukraine. Most of the assistance to the USSR, now Russia, has not reached the Ukrainian children.

Please let us know how we can assist you or the U.S. Senate in this matter.

Sincerely,

Andrew O. Lewicky, M.D.
President, Ukrainian Medical Association of North America

СВІТОВА ФЕДЕРАЦІЯ УКРАЇНСЬКИХ ЛІКАРСЬКИХ ТОВАРИСТВ

WORLD FEDERATION OF UKRAINIAN MEDICAL ASSOCIATIONS

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Dr. Achilles N. Chreptowsky
Chicago, IL USA

Executive Vice President
Dr. Myroslaw Kolensky
Chicago, IL USA

Vice President
Dr. Zenon Matkiwsky
Short Hills, NJ USA

Secretary General
Dr. Peter Mocniak
Chicago, IL USA

Financial Secretary
Dr. Lidia Kurylak
Chicago, IL USA

External Affairs Secretary
Dr. Oleh Wolansky
Kerhonkson, NY USA

Internal Affairs Secretary
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West Orange, NJ USA

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Dr. Iwan Daszkewycz, Poland
Dr. Lubomyr Pyrih, Ukraine
Dr. Oleksander Kucera, Ukraine
Dr. Andrew O. Lewicky, USA
Dr. Roman Prypchan, Venezuela

Kharkov, August 13, 1992

Dear Lesia Yevtukhy!

We were pleased to realize that the contents of your deposition to the U.S. Senate also expressed the long held view of the World Federation of Ukrainian Medical Associations.

We strongly endorse your proposals. While international aid has reached the USSR and Russia, the same has not been true in Ukraine. Our judgement, following our international meeting in Kharkov, Ukraine is that:

1. The Chernobyl tragedy poses many dramatic and unresolved medical issues in Ukraine.
2. Ukraine needs and welcomes medical assistance, both scientific and humanitarian.
3. Organization of "Center of Excellence"

27 Mockingbird Lane, Oak Brook, IL 60521 USA Tel: (708) 789-2721 Fax. (708) 789-2745 (over)

to link academic, professional and business organization representing Medical Science, Clinicians and Researchers private corporations to link U.S. with Ukrainian counterparts in an avenue to impact rapidly these diverse multi-disciplinary problems stemming from Chernobyl.

We wish you success in your goal to provide the U.S. Senate with the best available advice.

Sincerely,

Dr. Alexander Kotlarchuk
Executive Vice President

Yuri P. Maximuk MD
Secretary General

P.S.
Upon completion of U.S. visit would you kindly

Міністерство охорони здоров'я
РЕСПУБЛІКАНСЬКИЙ НАУКОВИЙ
ГІГІЄНІЧНИЙ ЦЕНТР
252660 Київ-94, вул. Попудренка, 50
тел. 559-73-73
для телеграм Київ-94, РНГЦ

18.08.92 № I.0I/II54

На №

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ
РЕСПУБЛИКАНСКИЙ НАУЧНЫЙ
ГИГИЕНИЧЕСКИЙ ЦЕНТР
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для телеграмм Киев-94, РНГЦ

ПАНУ ГОЛОВІ
АМЕРИКАНО-УКРАЇНСЬКОЇ
НАУКОВО-МЕДИЧНОЇ ГРУПИ

проф.В.Є.ВЕРТЕЛЕЦЬКОМУ

Вельмишановний пане професоре!

Головною науковою організацією України з питань охорони навколишнього середовища і його впливу на здоров"я населення є Український науковий гігієнічний центр /м.Київ/, що об"єднує 3 інститути і в якому працює більш як 300 науковців.

Оскільки питання, якими займається центр /медичні аспекти Чорнобильської катастрофи, захист генофонду населення України та інші/, на нашу думку, становлять міжнародний інтерес, ми висловлюємо глибоку зацікавленість в співпраці з інтернаціональними науковими організаціями.

В зв"язку із цим просимо Вас бути нашим представником у репрезентації української медичної науки в інтернаціональних структурах.

Маємо надію, що така співпраця сприятиме інтеграції нашої науки в міжнародну спільність.

Директор центру А.М.Сердюк

Translation of Support Letter

Ministry of Health
Republican Scientific Hygiene Center

To: Coordinator
U.S.-Ukrainian Medical Sciences Group
Dr. W. Werteleckyj Date: August 18, 1992

Distinguished Professor:

We represent the principle scientific Ukrainian organization concerning environment and its influence on the health of the Ukrainian people. We are constituted by three institutes which incorporate in excess of 300 scientists.

Our institutes are concerned with issues that include medical aspects stemming from the Chornobyl catastrophy, the protection of the genetic integrity of the Ukrainian population as well as other populations. We express our willingness and interest in collaborative projects with international scientific organizations.

In this regard we are asking you to become our representative and the representative of Ukrainian medical sciences in international organizations.

We hold the hope that collaborative activities will foster the integration of our scientists in the international community.

Signed: A.M. Serdiuk
Director of the Center
252660, Kiev 94
ul. Popudrenko 50
tel: 559-7373

ХАРКІВСЬКА ОБЛАСНА ДЕРЖАВНА АДМІНІСТРАЦІЯ

310022, м. Харків, Держпром, 8 під'їзд, тел. 43-21-05

13 08 92 № 01-13/475

На № _____ від

LETTER OF SUPPORT

Re: Depositon to the Senate of the United States of North America Concerning the medical care and scientific issues raised by the Chernobyl tragedy

Dear Dr. Werteleckyj

It was a pleasure to meet you and to study your deposition to the U.S.Senate.

On behalf of Kharkiv Region Administration which represents Region Council of People's Deputates, Kharkiv Medical Association and A.Maselskyj, A.Zdorovyj, V.Tyaglo, L.Pidoprygora, L.Porokhnyak, I wish to to support your views.

Your deposition raises issues about the urgent need in Ukraine for technical, scientific and humanitarian medical assistance. In this regard I would like to point out:

1. The need is urgent. Assistance is most effective if medical sciences address humanitarian needs concurrently.

2. We support the view that in addition to govermental programs, one-to-one bilateral programs between individual scientists, clinicians, clinics, hospitals or institutes are probably more effective.

3. The concept of joint "Ukrainian-American Centers of Excellence" is likely to lose and speed-up the comprehensive multidisciplinary long term and stable development of linkages

Друк. ф. "Харків. ун. М. В. Ф. [illegible] Харків, вул. [illegible] 2-26-[illegible]

Such "Centers" are also attractive because academic, private or state, plus business organizations can participate in creating or using such "Centers".

Concerning Chernobyl, international medical assistance to Ukraine per se has been modest. We also recognize the need for novel approaches beyond those already in place and promoted by International Agencies. New approaches such as the "Centers" are worthy because they fall outside of the existing frameworks. The "Centers" would attract considerable interest from our emerging private sector concerned with medical technology.

I take this opportunity to express my best wishes.

Vice-Chairman Of Kharkiv
Region Administration

A.Zdorovyj

U.S. Senate

Committee on Environment and Public Works

Statement of

Edward E. Purvis, III

Assisted by

Dr. Marvin Goldman

July 22, 1992

57-583 - 92 - 4

Statement of
Edward E. Purvis, III
Principal Engineer
Los Alamos Technical Associates, Inc.

July 22, 1992

Mr. Chairman, my name is Ed Purvis. I am a principal engineer with Los Alamos Technical Associates (LATA), an environmental sciences and engineering firm that provides technical services to industry and government agencies. Our principal work is in the fields of hazardous and radioactive materials handling and processing, national security, the environment, and nuclear safety. LATA has appeared in the Inc. 500, an elite group of the nation's fastest growing companies, and has been in the Engineering News Record's list of the top 500 design firms since 1981. LATA is currently involved in nuclear safety and nuclear cleanup programs in Russia and in Ukraine.

In 1986, I led the Department of Energy's Analysis Team's work to understand the Chernobyl-4 accident. Subsequently, we did extensive and detailed analyses and reviews of the safety of the Chernobyl type reactors, of the various models of VVERS (Soviet designed pressurized water reactors) and other Soviet designed nuclear facilities. Results were published in DOE/NE-0076, which addresses the Chernobyl accident, and DOE/NE-0084 and DOE/NE-0084 which address VVERs. My recent activities have included waste management, nuclear safety, and work related to cleaning up the aftermath of the Chernobyl-4 accident.

I was assisted in the preparation of this statement in regard to health effects of the Chernobyl accident by Dr. Marvin Goldman, who is extremely knowledgeable in this area. He is the leader of the US/USSR joint working group on health effects. He is Emeritus Professor of Radiology at the University of California at Davis, recipient of the Health Physics Society's Distinguished Scientific Achievement Award, and has chaired many committees assessing health effects of radiation.

I appreciate this opportunity to discuss the Chernobyl accident and its results, the current status, the continuing threat posed by the results of the accident, particularly in the area near the sarcophagus covering Chernobyl-4. It is necessary to understand the accident sequence in order to understand the resulting and current situation.

What Happened

The Chernobyl accident resulted from major design flaws and operations problems. The design flaws allowed the power output to increase as the temperature increased at low power levels. The control system could not shut the reactor down fast enough to prevent a problem under these conditions. (This was a unique problem with the Chernobyl type reactors which does not exist in water-cooled reactors in the West.) To avoid this problem, the Soviets established hard and fast rules prohibiting operation at the relatively low power levels where this flaw existed. At Chernobyl there was an operations problem that resulted in the continued operation of the reactor in violation of these rules.

The combination of design flaws and operator actions resulted in a situation where the reactor power increased very rapidly. The accident is estimated to have released over 32 gigajoules of energy in less than 0.2 seconds. The temperature of a small part of the fuel exceeded 13,000 degrees F. This vaporized the fuel. The expanding fuel vapor and fission product gases reacted with the water that cooled the reactor. The pressure tubes failed. There was a large pressure pulse that destroyed the reactor, blew fuel out of the reactor, and released highly radioactive material to the environment. Most of the fuel remained inside the area now covered by the sarcophagus. This fuel was extremely hot (4,000 degrees F) and was in contact with the graphite that had been broken into small pieces, causing the graphite to burn. The high temperatures of the fuel and the burning graphite resulted in some of the radioactive fission products being carried by the release plume thousands of feet into the air and being widely dispersed. Over 50 million curies were released.

Some important information could not be obtained. For example, the exact amounts of radioactive iodine and its distribution will never be known. There was no monitoring system to take the measurements and the iodine decayed very rapidly. Radioactive iodine absorbed into the thyroid gland is a major health risk, particularly in children. The longer-lived cesium was measured, but the dispersion of this isotope could have been very different from iodine. There is a very good, detailed report by the International Atomic Energy Agency that describes the releases and their distribution based on the available information. There are major uncertainties with the available data. To define the amount and characteristics of radionuclides in a territory of several thousand square miles is very difficult. For example, plutonium is essentially an alpha particle emitter and strontium-90 is a beta emitter. Measurements must be done with soil samples. Although thousands are required for a detailed map, only a few hundred sample analyses were made in the first year and half after the accident. These are insufficient to map contamination in detail for these isotopes.

There is reasonably good information on the fuel release and conditions in and near the sarcophagus.

The Situation In and Near the Reactor After the Accident

The major releases and spread of radionuclides took place at the time of the accident and in the period ending May 6, 1986. Table 1 provides an estimate of some key radionuclides in the reactor at the time of the accident. Release rates were several hundred thousand curies per hour. Figure 1 shows the release rates of radionuclides from the reactor in the period immediately after the accident. The entire inventory of radioactive noble gases was released, as was at least 20% of the iodine. Current estimates are that about 30 to 40% of the core inventory of cesium-137 was released from the area now covered by the sarcophagus.

TABLE 1. INVENTORY OF SEVERAL RADIONUCLIDES IN THE UNIT 4 REACTOR PRIOR TO THE ACCIDENT

Radionuclide	Half-life	Total Mass [kg]	Total Activity [Bq]	[MCi]
90 Strontium	82.6 years	44	2.2E+17	6.0
106 Ruthenium	368.2 days	6.9	8.6E+17	2.3E+1
134 Caesium	2.06 years	3.2	1.5E+17	4.1
137 Caesium	30.17 years	81	2.6E+17	7.0
144 Cerium	284.3 days	33	3.9E+18	1.1E+2
238 Plutonium	87.4 years	1.5	9.4E+14	2.5E-2
239 Plutonium	24,110 years	412	9.5E+14	2.6E-2
240 Plutonium	6553 years	176	1.5E+15	4.0E-2
241 Plutonium	14.7 years	50	1.8E+17	5.0
242 Plutonium	376,000 years	20	2.9E+12	7.8E-5
241 Americium	433 years	1.1	1.4E+14	3.7E-3
243 Americium	7,380 years	1.3	9.7E+12	2.6E-4
242 Curium	162.8 days	0.36	4.3E+16	1.2E-0
244 Curium	18.11 years	0.14	4.3E+14	1.2E-2

A small fraction of the fuel was vaporized and the fine condensed powder dispersed over a large area. A larger amount was dispersed as fine fuel fragments. Some fuel elements were thrown on to the roof of the building (Figure 2 shows a worker cleaning up graphite and fuel that was thrown from the core onto the top of the building) and into the yard outside the building. Most fuel remained in the destroyed building.

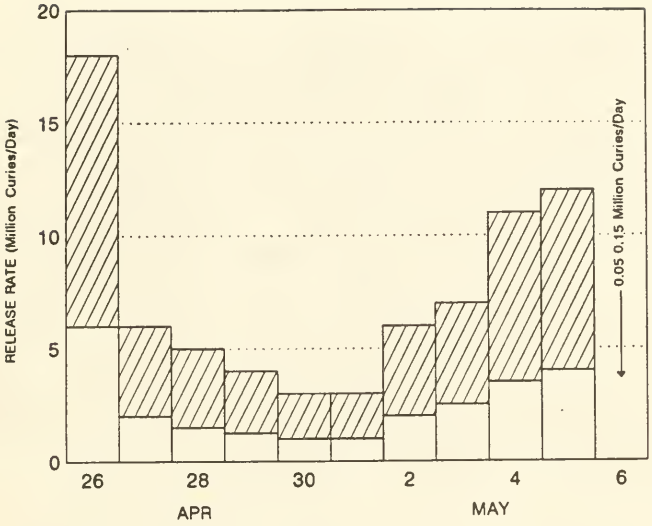

Figure 1. Estimates of Radioactivity Releases from the Reactor After Chernobyl-4 Accident

There were about 420,000 pounds of fuel in the reactor core at the time of the accident. It is now estimated with good confidence that between 3 and 4% (12,600 to 16,800 pounds) of this fuel was released from the volume that is now covered by the sarcophagus. While the larger pieces of fuel and fuel elements were found and collected, smaller fuel fragments could not be collected. The remainder of the fuel (over 400,000 pounds) is in the sarcophagus.

The ground around the sarcophagus was scooped up and buried in pits within ten miles of the plant. Much of the contamination gathered in the cleanup immediately after the accident was buried in these pits. Many of the vehicles and most of the equipment used in the cleanup were also buried in pits. The water table around the Chernobyl reactor site is close to ground level, so there is a danger that this contamination is being spread into the water table.

Over 5,000 tons of material (40 tons - boron carbide, 800 tons - dolomite, 1,800 tons - sand and clay, 2,400 tons - lead) was dropped over the reactor from helicopters between April 28 and May 2, 1986 to reduce releases of radionuclides. Through June of 1990 over 14,000 tons of material was dropped on the reactor. Much of this material melted and combined with fuel, graphite, and material in or near the core to

Figure 2. A Worker Removing Core Debris from the Roof of Chernobyl-4 After the Accident

form "lava." This material ran through pipes that were in the core area to vent steam from pressure tube failures to water-filled suppression pools under the reactor (Figure 3, a cross sectional view of the Chernobyl Unit-4, shows these pools). Figures 4 and 5 show the "lava" in the pipes and pools. The gamma radiation dose rate on the surface of some of the pipes and "lava" in the summer of 1986 was on the order of 10,000 r/hour. At some locations the dose rate was about 20,000 r/hour.

Most of the approximately 400,000 pounds of fuel that remained inside the sarcophagus is either in this "lava," or is present as dust and pieces of fuel on what used to be the operating floor of the reactor. The vessel that held the core is almost empty, although the region underneath contains most of the fuel in lava.

Figure 6 is an isometric sketch of the reactor that shows the reactor and adjacent regions.

The Sarcophagus

A number of heroic actions were taken after the accident. The water was removed from the suppression pools to prevent a steam explosion and associated radionuclide release that would have occurred if the core had melted through the concrete and fell into the water. A 400-foot tunnel was dug to allow liquid nitrogen to be injected into the core area to cool the core.

It has been found that the hot fuel had penetrated into the concrete under the core that was originally 6.6 feet thick, until only 8 to 20 inches of good concrete remained in some places.

The sarcophagus (Figure 7 is an isometric sketch of the exterior and Figure 8 is a cross-sectional view of the interior) was erected in a very short period of time to reduce releases. Figure 9 is a picture of the reactor after the accident. The sarcophagus that was erected over this destroyed building was not a containment structure or a long-term solution to the problem. In order to reduce immediate risks to people and the environment, the sarcophagus was designed and built very quickly under emergency conditions, in a very dangerous radiation zone.

The Current Situation in and Near the Sarcophagus

Figure 10 shows recent radiation levels in the suppression pools.

There are fuel fragments, fuel assemblies, parts of fuel assemblies, and fuel rods spread about what used to be the operating floor of the reactor. There is finely dispersed radioactive dust, called "hot particles,"

Figure 3. Cross Sectional View of the Main Building at Chernobyl-4

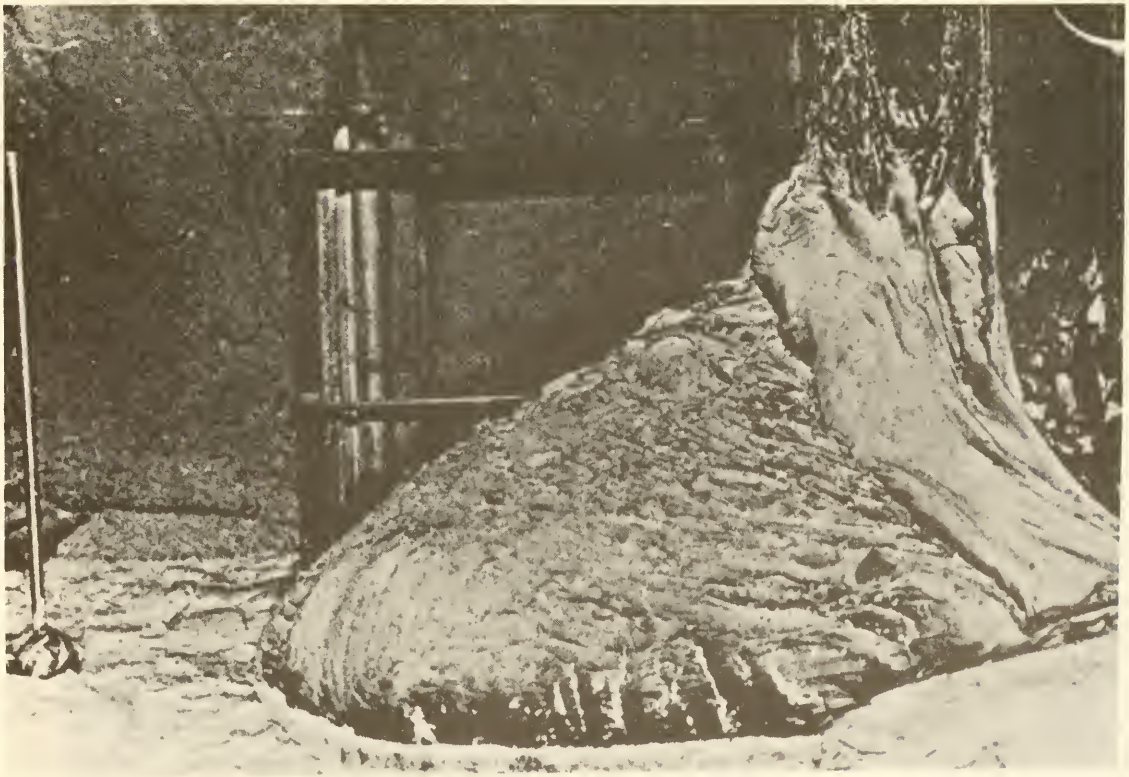

Figure 4. The Elephant's Foot--A Mound of Lava Containing Fuel in the Chernobyl-4 Suppression Pools

Figure 5. Solidified Lava Flowing From a Pipe in a Chernobyl-4 Suppression Pool

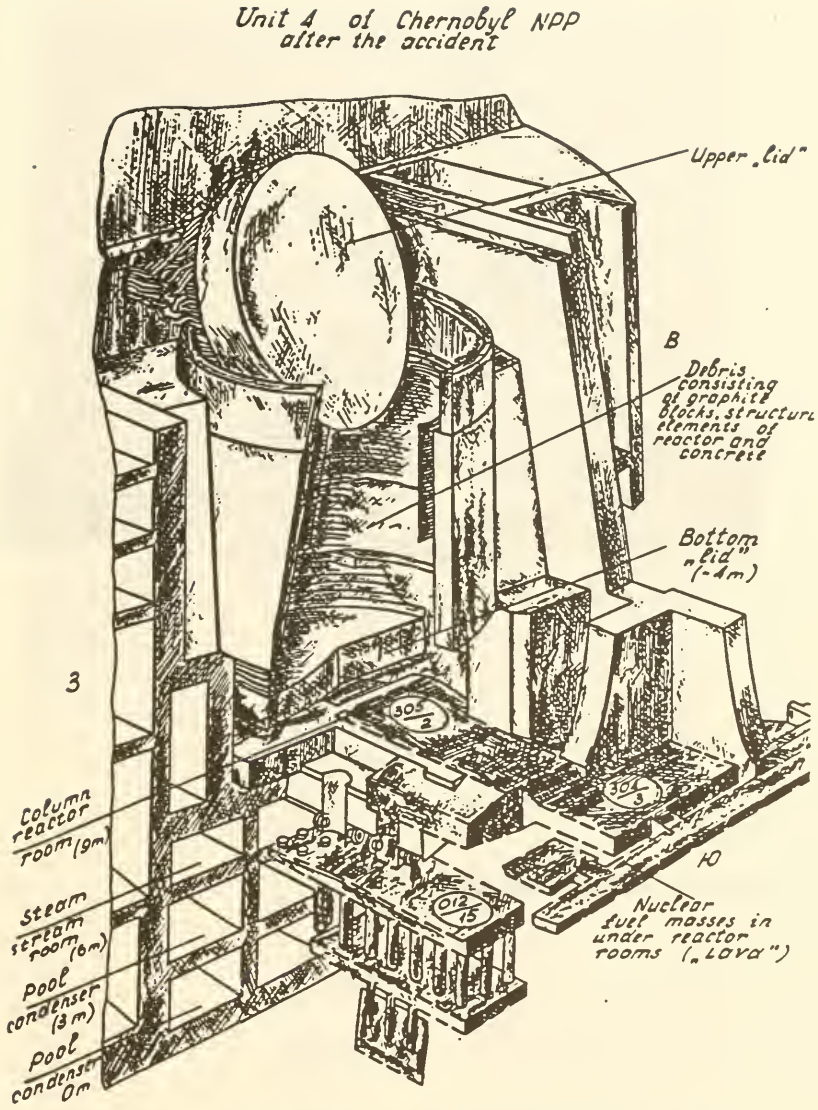
Unit 4 of Chernobyl NPP
after the accident
Upper „lid"
B
Debris consisting of graphite blocks, structural elements of reactor and concrete
Bottom „lid" (-4m)
3
Column reactor room (9m)
Steam separator room (6m)
Pool condenser (3m)
Pool condenser 0m
Nuclear fuel masses in under reactor rooms („Lava")

Figure 6. Isometric Sketch of the Reactor Showing the Core and Adjacent Compartments

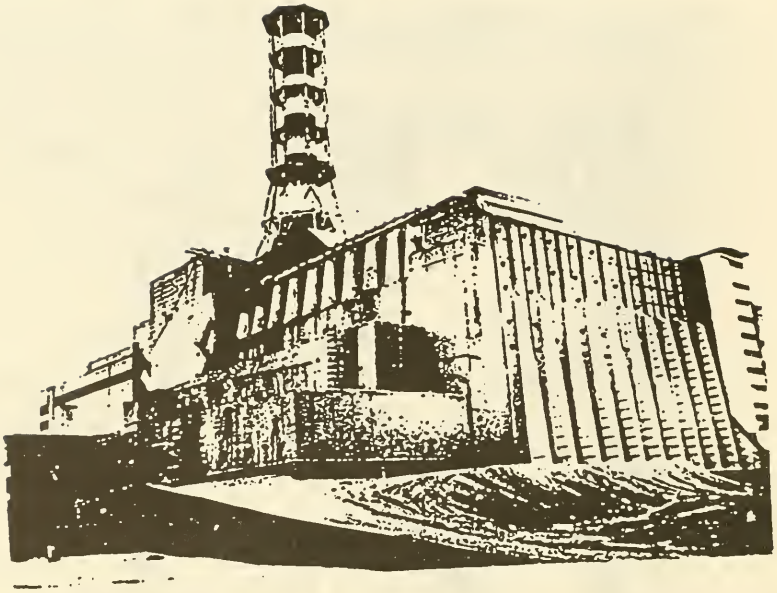

Figure 7. External View of the Sarcophagus

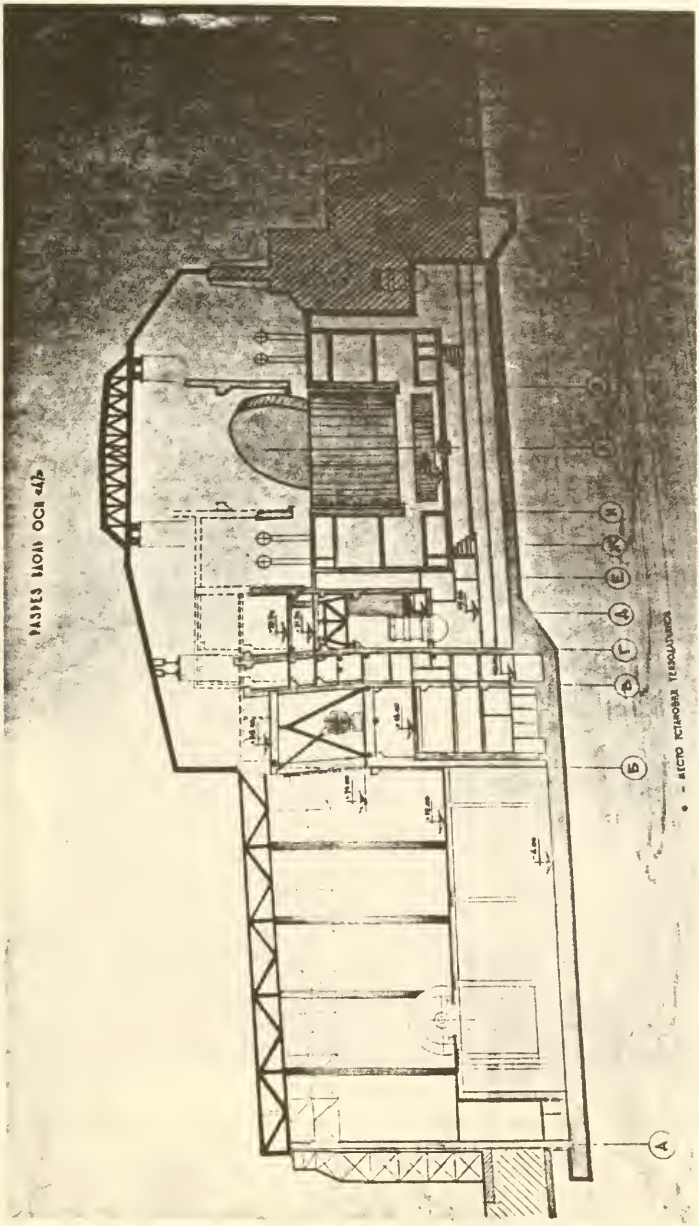

Figure 8. Cross Sectional View of the Sarcophagus

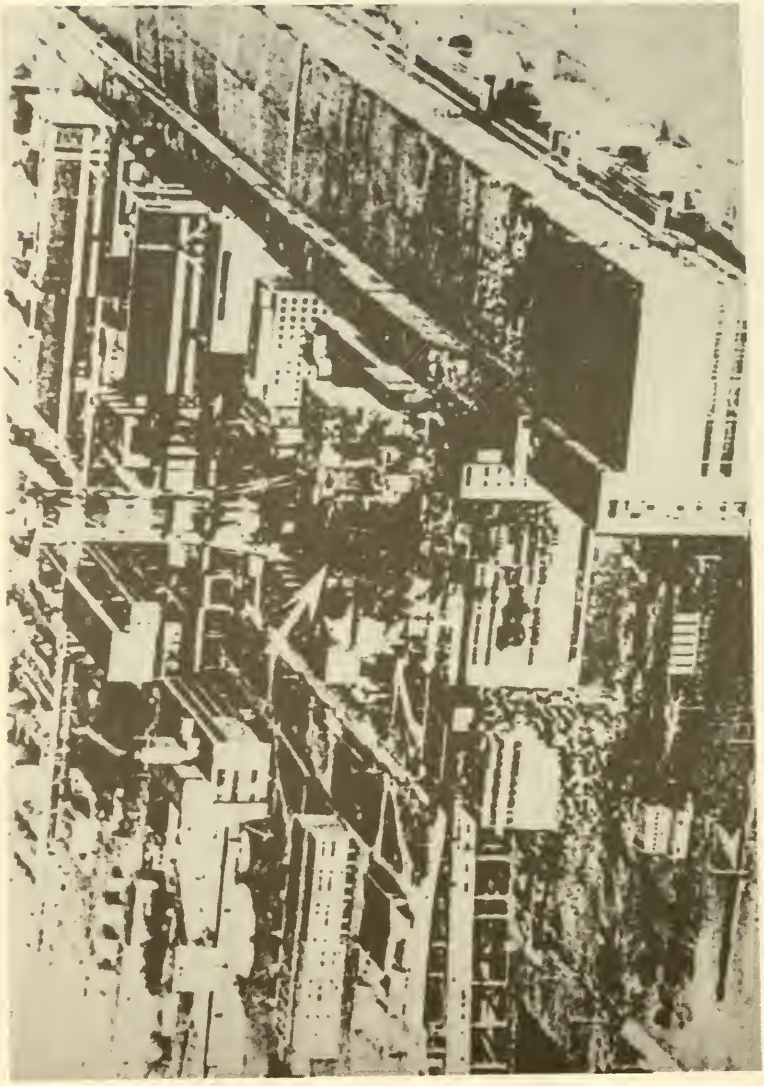

Figure 9. Picture of Chernobyl-4 After Accident

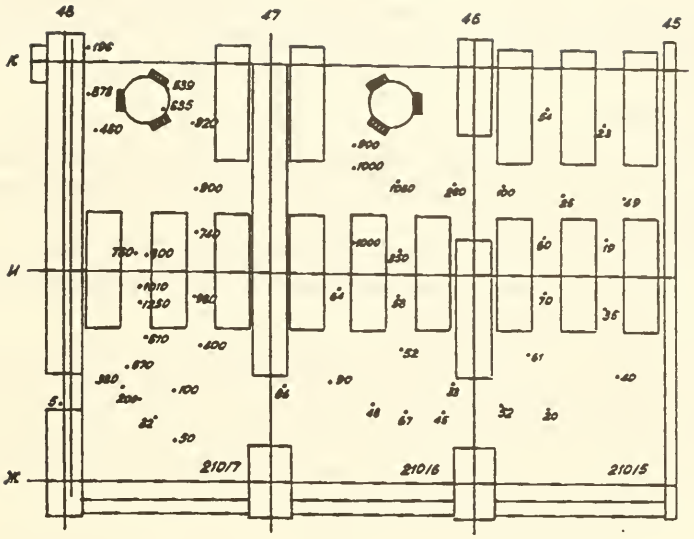

Figure 10. Radiation Levels in the Suppression Pool Under Chernobyl-4

throughout the sarcophagus. This dust was produced during the accident and coated everything, some as an aerosol. Then there is the "lava," some in the form of a glassy material, some like pumice, and some in between, but all containing significant amounts of fuel and radioactivity. The fuel distribution in the "lava" in the sarcophagus is shown in Table 2.

TABLE 2. FUEL DISTRIBUTION IN LAVA IN SARCOPHAGUS

Location	Level (meters)	Mass (tonnes; accuracy 35%)
Pressure suppression pool	0	1.6
Pressure suppression pool	3	11
Steam distribution corridor	6	23
Reactor bottom room	9	75
Premises with lava	9	20
Other fuel clusters	0 to 9	4
Total	0 to 9	approximately 135

The information on the conditions in the sarcophagus was obtained in significant detail as a result of much courageous and hard work by dedicated workers at the reactor.

The Current Risks

While radiation release rates from the sarcophagus are now low, much of the fuel and remaining radioactive material is in a form that potentially could be dispersed under a number of conditions. Examples of release mechanisms are:

- The over 2,000 ton reactor cover is tilted on edge. Its stability is unknown. If it falls it will create a big cloud of radioactive material.

- Birds, insects, and animals live and feed in the sarcophagus. They carry radioactive material outside of the building.

- The sarcophagus is open to the environment. Releases increase under some weather conditions, sometimes by a significant amount.

- The sarcophagus is deteriorating rapidly. Steel portions are rusting. Concrete is cracking and crumbling in places.

- The immense structure of the sarcophagus is settling unevenly. The area of the openings is about 13,000 square feet, and the number and size of the existing openings are increasing.

In addition, there are large amounts of radioactive material buried in pits near the sites. This material is entering the water table and could move into the food chain, creating health risks.

It is known that there are hot spots outside the exclusion area. The limits and contents of these hot spots are ill defined. The population in the area that received fallout are receiving increased exposures over normal background, particularly in the areas of the hot spots. The population in the areas that received fallout is at an increased risk over people in other areas. Due to uncertainties in understanding both the effects of low levels of radiations, and details of the exposures and distribution, it is not possible to quantify the extent of this risk.

Natural processes of decay have reduced the levels of the released radiation to about 15 or 20% of the original levels. Further reductions in levels of radiation will be slow. The most intense and damaging doses occurred in the period immediately after the accident.

The health risks associated with exposure to radiation from the accident has not been eliminated; it has been greatly reduced.

There are also risks that result from past exposures. The population at greatest risk are the small children who received thyroid radiation exposures due to iodine immediately after the accident, and the "liquidators" who worked on the site cleanup and emergency response actions after the accident.

Using existing knowledge and technology, it is possible to reduce future exposure and risk with prudent cleanup activities. The level of risk is still high enough to justify these actions. The need for some action such as containing, or isolating, major potential release sources such as the sarcophagus, the burial pits where the debris from the emergency cleanup action was taken, and the hot spots is obvious. The need for other cleanup actions must be addressed on a cost/benefit basis with the benefit criterion being the greatest reduction in human health risk for available funds.

Problems

The key problem in taking needed action is the lack of hard currency. The cleanup of the Chernobyl accident does not produce a revenue stream. International lending agencies and banks need to have a revenue stream to provide the funds to assure repayment of the loan if normal banking practices are used. Unfortunately, measures to reduce the remaining health risks to the population do not provide such a definable revenue stream. While cleanup and risk reduction have both a human and economic benefit, it is difficult to quantify this benefit in conventional "bankability" terms.

Needed Actions

Ukrainian people, equipment, and currency provide the vast majority of the resources required to clean up Chernobyl. There are also needs that require external resources, such as technology. The work in the sarcophagus, for instance, cannot be done with people because the radiation exposures are too high. (In fact, much of the work that has been done to date has been done by people working in radiation fields that would be unacceptable for people in the United States.) Work must be done with remote devices and robots, not people. Only when the radiation levels are reduced can people work in this area.

Work must be done in a logical sequence:

- First, the radioactive material in the sarcophagus must be stabilized. This requires remote equipment.

- Second, the fuel, the dust, the lava, and the other loose radioactive material must be collected and put in containers and placed in a safe repository. Much of this requires remote equipment.

- Third, the remaining radioactive materials must be either confined or decontaminated, and cleaned up. This will require a mix of remote equipment and people.

Evaluations to select a long-term solution need not delay priority near-term actions. A long-term solution can be applied after necessary precursor actions are taken. Long-term solutions might include placing a stable confinement structure around the reactor (after cleanup), or a more detailed cleanup.

There are two major options, confinement versus "green fielding". This choice, and actions between these two extremes, are the subject of deliberation.

There are numerous other examples of needs that require U.S. technology and expertise to allow work to be accomplished in a safe and efficient manner. Details have been identified and will be applied as soon as possible.

The Help Needed

There are some things that can be done with Ukrainian funds and these will constitute the vast bulk of the effort and manpower.

Hard currency is required to provide resources and technology that are not currently available in Ukraine. The current economic situation exacerbates a very difficult situation in terms of financing the hard currency portion of the cleanup work. This work must be done first because, despite the bravery and risk accepted by workers at the reactor to assess the details of the situation inside the sarcophagus, people cannot perform many of the tasks required to stabilize and contain the loose material. Technology and expert help is required to allow the work to be done.

Clean up actions should be taken as quickly as possible. The problems created by the Chernobyl-4 accident still exist. While smaller than the problems immediately after the accident, they are still significant. Future reductions in health risks due to natural processes will occur slowly.

The current economic situation does not provide mechanisms for Ukraine to generate the needed hard currency. Significant amounts of hard currency must come from outside Ukraine to allow work to proceed expeditiously.

The key need now is hard currency to allow remedial actions to proceed.

Thank you.

Attachment A

Health and Environmental Problems in Ukraine from the Chernobyl Accident

by Marvin Goldman

July 13, 1992

I was asked by Ed Purvis to supply a brief statement on the current issue of Chernobyl-induced health and environmental effects. I have been studying these since the accident and have been to the former Soviet Union 11 times on this issue. As scientific group leader for the USA/USSR Working Group 7.2 on Health Effects of the Joint Coordinating Committee on Civilian Nuclear Reactor Safety, I have been working with our scientific counterparts over there for the past 4 years. This statement reflects my own personal opinion and does not necessarily represent the official position of any official US Government agency.

The Chernobyl accident resulted in the dispersion of massive quantities of radioactive materials over most of the Northern Hemisphere. However, the region close to the reactor, especially where it rained while the plume was passing overhead, was particularly hard hit. Large areas of Ukraine, Belarus, and Russia are still "coated" with a mantle of radio-cesium, an isotope with a 30-year half life, "strong" gamma and beta radiation, and a metabolic similarity to potassium in that it is ubiquitously passed through the food web to people. Simply stated, it poses a threat for total body exposure from external depositions as well as from ingestion of contaminated food stuffs.

The other radiation of significance is more serious in my estimation. The short-lived isotopes of iodine, which were released in very large quantities, delivered high radiation doses to the thyroid glands of thousands of people down wind. Most importantly, even larger doses were delivered to children because of their greater consumption of contaminated milk, and because of their smaller and more active radiosensitive thyroid glands. The children received doses several times higher than their parents and, unfortunately, some of the children are already demonstrating a higher than normal incidence of thyroid cancer. The exact figures are not yet available, but there appears to be an increase in childhood cancer in Belarus and Ukraine. It will be important to perform a credible job of retrospective dosimetry as well as of epidemiology in order to precisely quantify the risk. All I can say at this time is that there is a real problem, and it is increasing.

A special problem is associated with the many thousands of people who were recruited to help with the cleanup and other post-accident activities. About a half million people were involved, and perhaps about 10% of them, many in the military, received significant exposures. This latter group is restricted mainly to

those involved in 1986 and part of 1987. There are reports of increased death rates, but no completed scientific study is yet available to determine if any of the reported deaths are radiation related, or what doses were absorbed. The continual publicity on this issue cannot be ignored, and it is important that a credible dose reconstruction and health survey be performed. This contributes to the next issue as well.

Another issue today is related to the level of distrust and confusion associated with the real and imagined radiation exposure of the public. This has induced a massive "epidemic" of radiophobia, a fear of what the radiation may have done, but which is not yet manifest. This psychological effect is not to be ignored, because to the people it is very real, and fear is possibly increasing as a result of misinformation, disinformation, lack of correct knowledge, etc.

Reports of predicted extra cancer deaths from the accident have used a variety of models and assumptions. Basic to all is the fact that most late effects of radiation appear many years after exposure, and are yet to "be counted." In addition, the risk models for extra cases over the next 45 years or so predict anywhere from about several hundred to a third of a million.

In discussing radiation risks, I choose to use a concept of risk increment. There is no dose so small as to have no associated risk, i.e., there is no threshold of safety. That is, whatever a person's lifetime cancer risk may be, a dose of radiation adds an increment to it. A common value in western countries is that about one in five people die of cancer; the risk is 1/5 or 20%. Assume that a radiation dose equal to 50 years of natural background radiation increases ones cancer risk by 1%, i.e., about 1% of the 20% cancer risk can be ascribed to natural background radiation. This is about the value most responsible scientists seem to accept. With few exceptions, the thyroid being the dominant exception, almost no one in the Chernobyl down-wind areas received such a dose. Even the very best epidemiology study cannot distinguish between two such groups, no matter how large the groups studied. Therefore, we are faced with the problem of micro doses to mega populations, a situation where direct measurement can only confirm that the doses were small, but not that absolutely no health consequences resulted.

My current conservative estimate is that no more than 5,000 to 10,000 additional cases could be caused by the accident; the same model also states that the possibility of zero extra cases is not ruled out statistically. The truth will likely lie in between, closer to zero than the upper value. But this is not a certainty; it is an estimate based on my understanding and evaluation of doses and risks.

There have been reports of a spectrum of alleged health "effects," most of which were likely not to have been caused by Chernobyl's radiation. The task of separating the real from the alleged is formidable.

Only a careful, credible dose reconstruction and a set of specific epidemiology studies will provide the evidence to put the issue into perspective.

It is possible that there may be "pockets" where a time-specific increase of leukemia may occur. There may be more cases of thyroid cancer in the afflicted areas, the result of doses completely delivered 5 years ago. It is not likely that there are many areas where people are now living, where relocation is necessary to reduce the lifetime dose by a significant fraction of what has already been absorbed. It is possible that almost everyone exposed has already received over 90% of their Chernobyl doses. Without further data and information, it is not possible to state whether this optimism is solidly founded. I can only end by stating that, other than what I've outlined above, the radiation doses from the accident are not expected to deliver any more surprises.

PREPARED STATEMENT OF MURRAY FESHBACH, PH.D.

I, of course, would like to thank the committee and its staff for inviting me to testify about this important issue. My viewpoint is that the situation is much worse than hitherto deemed to be the case, and that new evidence confirms the rising problem.

First, please allow me to stipulate that I am NOT opposed to nuclear power, per se. I am opposed to the way the Soviets did and the newly independent states continue to operate their facilities. This is the hazard that particularly disturbs me because I believe that it is a potential hazard not only for the former Soviet Union's population, but also for the populations of Europe, the Far East and Canada and the United States. Soviet facilities are potential accidents waiting to happen. I include in this not only the Chernobyl-type reactor but all others, as well as the nuclear waste and reactor dumping sites in the Novaya Zemlya region, and the approach to the northern seas of radiation moving from Chelyabinsk region through the Siberian rivers.

Second, to address the Chernobyl situation more directly. It should be made clear that the original report on the number of territories affected by the accident of 25 April 1986 is a major understatement. According to the original, somewhat delayed report, only 5 administrative-territorial units—known as oblasts (roughly equivalent to our state-level unit)—in Ukraine, Belarus and Russia were impacted. The current information available indicates that the total of 4 oblasts in Ukraine and Belarus hold, but instead of 1 oblast in Russia, 15 were affected by at least an average of 1 curie of radioactivity of cesium–137 radionucleides per square kilometer.

Included in this category of at least 1 curie per square kilometer is not only the originally reported Bryansk oblast (over 34 percent of the oblast territory), but also Kaluga oblast (17 percent); Belgorod oblast (8 percent); Voronezh oblast (1.5 percent); Rursk oblast (4.4 percent); Leningrad oblast (1 percent); Lipetsk oblast (8 percent); Orel oblast (40 percent); Penza oblast (3 percent); Ryazan oblast (15 percent); Smolensk oblast (0.5 percent); Tambov oblast (1.7 percent); Tula oblast (47 percent); Ulyanovsk oblast (0.6 percent); and Mordovia (2 percent);

Areas with less than 1 curie per square kilometer affected, i.e., 0.5 to 0.6 curies per square km: Tver, Novgorod and Nizhnegorod oblasts;

Areas with less than 0.4 curies per square kilometer: Saratov oblast and Udmurtia;

Areas with less than 0.3 curies per square kilometer: Rarelia;

Areas with less than 0.2 curies per square kilometer: Astrakhan, Kaliningrad, Rostrom and Rostov oblasts, plus Chuvashia and Kalmykia;

Areas with less than 0.1 curies per square kilometer: Arkhangel'sk, Vladimir, Volgograd, Vologda, Ivanovo, Kirov, Srnara, Moscow, Murmansk, Orenburg, Perm, Pskov and Yaroslavl oblasts, Stavropol kray, Bashkiria, Mariy El and Komi ASSR's.

An indeterminate, as yet, number of curies per square kilometer is known also to be prevalent in the Siberian and Far Eastern regions beyond the Urals, but the trace rnounts have not yet been determined. Apparently a survey is being conducted presently.

Whether hazardous or not, the spread throughout the former country is much greater than indicated previously.

Third, the renowned International Atomic Energy Agency report about the impact of Chernobyl on health, is, in my humble opinion, wrong. It is wrong for at least 4 reasons, not due to the brilliant people, physicists, medical personnel, epidemiologist, and others, but for other reasons:

1. The analysis (whether asked for or not by the then Soviet government) was conducted much too early to see the impact of low doses of radiation on the health of the population. Undoubtedly the latest data they could have had was for 1989, only 3 years or so after the event. Given the experience of the health impact on the Biroshima and Nagasaki populations, some 5,6,7 years later is when the peak incidence of leukemia and thyroid cancer shows up (again from low exposure levels), not 2 to 3 years;

2. Every Soviet analyst, epidemiologist, government advisor, and green party member I asked about the conduct of the IAEA analysis indicated that they, the IAEA researchers, did not ask about,, more likely did not know about, the Third Administration of the USSR Ministry of Bealth. It is this organization which collects data, supervises analysis, and keeps secret the data from nuclear events such as Chernobyl as well as chemical and biological accidents. The Institute of Biophysics, under Academician Il"it seems more attached to the military than to the Academy of Medical Sciences. Many Sovietologists did and still do not know about the

Third Administration. This organization reportedly had medical information about 500,000 persons involved in the region and the clean-up process.

3. The sample was too small, including only 100,000 persons still resident in the region, and not those who left to return to Estonia, Latvia (5,000), Central Asia, especially Uzbekistan (12,000) or elsewhere within the former USSR—and therefore whose morbidity and mortality (either short-run or now longer-run) were not incorporated in the sample. The total number of persons involved should have been 660,000. According to the Balts, many of these individuals, especially young military reservists called up explicitly to help in the clean-up, became very ill or died.

4. Testimony to the IAEA investigators was provided and ignored. On the one hand, I can accept with alacrity that there are many diagnostic errors in Soviet medicine (then and now), and I have written (with Alfred Friendly, Jr.) a major book on health and environmental issues (entitled Ecocide in the USSR: Health and Nature Under Siege, New York, Basic Books, 1992, 376 pp.) explicitly detailing all the problems of Soviet medicine. On the other hand, to completely ignore some of the evidence is a bit much. One physician from Zhitomir oblast showed me his data (which he twice presented to the IAEA investigators), on the growth of congenital anomalies from the period 1985 to 1989. For every subadministrative territory of the oblast, he had rayon data for every single birth in the oblast, and their medical status. Be found a growth of 2.5 to 7 times for all types of congenital anomalies since the base year, 1985, the year before the accident. If one even reduces any putative exaggeration, mis-diagnosis, by even 50 percent, the increase in anomalies in this impacted region in such a short time is more than noteworthy. Why were these data not incorporated? Others tell me that suggestions for specific areas to visit also were ignored or unarranged?

5. Current data show an explosion of cases of thyroid cancer in the region. Some selected data are, as follows:

a. In late March 1992, the Ukraine's Parliamentary Commission on Chernobyl affirmed that 37 Ukrainian and Belorussian children were diagnosed with thyroid cancer in 1991 and 1992. Prior to the accident, only 1 or 2 cases per year were reported;

b. In mid-April 1992, the Belarus Parliament was informed that 1,700 cases of thyroid cancer were recorded in the republic/country at the beginning of 1992, with 35 children so afflicted. Prior to the accident, for the 20 years up to 1986, only 5 adults and no children were diagnosed with thyroid cancer. Since the beginning of the year, another 299 persons, were "officially recorded," including 52 children in the first few months of 1992 (subsequent to the 1,700 count). Bow many were not unofficially recorded, or incorrectly diagnosed? Incorrect diagnoses can work in both directions—undercounts due to misdiagnosis and non-recognition, or exaggerated overstatements of the seriousness of the given illness. The disparity pre- and postChernobyl is enormous even were one to multiply the base period by 10 or 20 and halve the later figure (say 200 and 850, respectively).

c. At the Belarus Congress on Chernobyl, held in April of 1992, a speaker indicated that "almost 200,000 Belorussian children now have enlarged thyroids." Bow many will progress into thyroid cancer is not known, but certainly if one assumes as little as 5 percent, this would be 10,000 additional cases;

d. In Ukraine, the rate of thyroid cancer has increased by 17 times in the period 1986 to 1991, from a rate of 0.13 cases per 100,000 population up to its present level, or 2.2 per 100,000 population;

e. The Ukrainian Minister for Clean-up of Chernobyl stipulated in the spring of this year that 6,000 to 8,000 excess deaths occurred due to the Chernobyl accident. Again this is for Ukraine only and not for Belarus, Russia, Estonia, Latvia, and other republics/countries.

f. The Ukrainian Minister of Environment, Yuri Shcherbak, stated that "potential mortal doses of radiation were suffered by 365,000 persons (for Ukraine only). By this time, 7,000 persons who participated in the emergency work have died." Not 32 persons as initially admitted and not the 150 later admitted, according to official statistics, but 7,000 as a minimum for excess deaths.

To repeat, even if most of these statements by local authorities are exaggerated, even by doubling the true levels and rates, they are significantly more than Soviet official or the IAEA results.

To indicate that radiophobia is widespread (from the results of the latter's survey) is not surprising. If it were not so, then I certainly would believe that this report was erroneous for this reason alone. I was then in Belgium, serving as the first, experimental Sovietologist-in-Residence in the Office of the Secretary-General of NATO, Lord Carrington, at the exact time of the accident. My wife and I were exposed to the radioactivity that impacted that country as well. I can fully empathize

with those who are classified as phobic about radiation, but to classify all "illness" as phsychosomatic I cannot believe based on logic and the evidence from the republics/countries involved..

Thank you.

PREPARED STATEMENT OF SHELBY T. BREWER

Thank you, Mr. Chairman, for the opportunity to appear before your Committee. I am Shelby Brewer, Chairman, ABB Combustion Engineering Nuclear Power.

ABB Inc., headquartered in Stamford, Connecticut, offers an extensive portfolio of products and services that meet America's need for cleaner, more efficient ways to create and apply energy in communities and industries. ABB serves customers in several major markets, including producers and users of electrical power, pulp and paper manufactures, hydrocarbon processors, passenger rail authorities and automotive manufacturers. The company employs over 29,000 people at some 50 manufacturing facilities and 300 sales and service centers nationwide. We designed 15 of the operating reactors in the U.S. and they have had an excellent operating record to date.

ABB Inc. benefits from the strengths of its parent company, ABB Asea Brown Boveri Ltd. (headquartered in Zurich, Switzerland), which is the holding company of the ABB Asea Brown Boveri Group, a global leader in electrical engineering and technology with 214,000 employees around the world. In 1991, ABB Group revenues approached $29 billion, with the U.S. accounting for 19 percent of this total.

My purpose today is to present my company's perspective on the nuclear power complex in Commonwealth of Independent States (CIS) and Eastern Europe (EE).

CHERNOBYL AND THE RBMKS

Since the Chernobyl accident of 1986, the safety of nuclear reactors operating in Eastern Europe and the former USSR has been a subject of intense review and debate. Most western nuclear experts agree that the accident resulted from an inherently poor design combined with poor station operating procedures.

Moreover, the design inadequacies of the Chernobyl class of reactors (the RBMK type) are considered fundamental, deriving from the way the nuclear fuel and the coolant are configured, selection of materials, and the dynamics and control of the fission process itself. I will avoid a long technical dissertation on this subject, but the point is that most experts agree that safety deficiencies of the RBMK class cannot be retrofitted away, because they are so fundamental in character.

There are sixteen of these reactors in operation currently, supplying a significant fraction of electrical energy, particularly in Russia. While decommissioning of the RBMKs has been urged by western authorities, it is not clear how an electricity generating shortfall would be managed, if, indeed, such a gap would result from RBMK closure. The extent of a capacity shortfall, sans the RBMKs, is uncertain; electrical demand by the industrial sector in Russia is decreasing.

Management of an electrical supply shortfall could involve a mix of options such as:

- Repowering the RBMKs with combustion gas turbines, such as was done at the Midland and Zimmer nuclear plants in the U.S.;
- Efficiency improvements;
- Wheeling power from Western Europe;
- Completion of the 1000 MWe VVER type reactors under construction in the CIS.

Crosscutting the issue of continued versus discontinued operation of the RBMKs, the electrical energy supply/demand uncertainty, is the severe economic conditions Eastern Europe and CIS are facing as this region transitions from central economic planning to a market-driven economy. The constraints on hard currency purchases are enormous. This exacerbates the problems of the RBMKs—of exercising any of the options I have listed above, such as substitution of gas turbines for the RBMKs, purchasing power, or rapid completion of the 1000 MWe VVER-type reactors in the pipeline. How will these projects be paid for? It is not enough to hector and nag them about the safety of their technology, touting our own western technology. This region has a tough, complicated multi-dimensional problem which they need our help with, not our nagging, nor our condescension.

If we indeed believe that the RBMKs must be shut down, then we must suggest—suggest, not demand—reasoned alternatives, and offer ways that this region can generate economic value to pay for these alternatives.

It is ironic that after 70 years of lecturing the Soviet regime on the efficacy of market-driven economies and free enterprise, we threaten a trade barrier in 1992 on importation of CIS uranium and uranium enrichment services into the U.S. I refer, of course, to the "dumping issue" now before the Commerce Department. Sale of uranium and enrichment services is one of a very few means available to Russia to generate hard currency needed for reactor upgrades.

REACTOR TYPES AND LOCATIONS IN EASTERN EUROPE AND CIS

There are reactor types other than the RBMK type in Eastern Europe and CIS. The other principal reactor type is the VVER, a design conceptually similar to the Pressurized Water Reactor (PWR) prevalent in Western Europe, the U.S. and Asia. There are three principal series of VVERs:

- The VVER 440/230 series—a 440 MWe design developed and deployed in the 1956-1970 time frame—the first generation VVER.
- The VVER 440/213 series—a 440 MWe design developed and deployed in the 1970-1980 time frame—the second generation VVER.
- The VVER 1000/320 series—a 1000 MWe design developed and deployed in the 1970-1985 time frame—the third generation VVER.

The operating reactor types and locations are summarized in Table 1.

RELATIVE SAFETY OF EE/CIS REACTORS

As I mentioned earlier, safety issues regarding EE/CIS reactors intensified following the Chernobyl accident in 1986. While the Chernobyl reactor was an RBMK, the issue swept across all reactors including the various VVER series.

Numerous assessments have been conducted by national and international nuclear agencies evaluating the safety attributes of EE/CIS reactors. The IAEA, WANO, USNRC, USDOE, and others have conducted these studies. A good summary of these efforts was published by the USCEA in a "Source Book" in April of this year. These assessments form the bases for formulating western assistance plans for reactor remediation, e.g., G-7 and G-24. Without burdening you with the staggering detail of these studies, let me qualitatively summarize the major conclusions:

1. The RBMKs are inherently unsafe and should be brought off line as soon as possible.
2. Relative safety attributes of the VVERs varies from the first generation 230 series (worst) to the third 320 series (best).
3. Relative safety attributes of EE/CIS reactors, even the 320, 1000 MWe, series fall short of western standards.

This summary is admittedly an oversimplification and glosses over differences among the studies in detail.

EVOLVING NUCLEAR INFRASTRUCTURE IN EE/CIS

Traditionally, core competence in nuclear technology, research and development, reactor design and engineering and manufacturing for Eastern Europe and the former Soviet Union has resided in Russia. Manufactured nuclear fuel was supplied by Russia, and spent fuel was returned to Russia for disposition. Reactor equipment was supplied by Russia. (Some large component manufacturing was done in Czechoslovakia, but built to specifications established by Russian designers.) Safety regulatory standards were established in Russia. Economic transactions were accomplished in rubles.

The political restructuring in Eastern Europe threatens to change these traditional supply patterns as each EE/CIS nation strives to establish its own planning, supply, and regulatory infrastructure. This transition raises another nuclear safety issue: what effect will these infrastructure disruptions (decentralization) have on nuclear safety? Can new, competent, nuclear infrastructures be established quickly enough to economically assure a continuity of nuclear safety?

To me it makes no sense, given the other economic imperatives of the region, to write off the current more or less centralized nuclear infrastructure—to dismiss manufacturing and engineering and research and development resources in Russia—and then incur the expense of replicating this infrastructure in each of the newly independent nations. Yet this is exactly the tact some Western nuclear companies are on—to replace the Russia-based nuclear infrastructure with their own. In marketing new fuel manufacturing capability for EE/CIS, for example, they cite the need for nuclear independence from Russia and the usual time-worn cliches about Russian quality.

Infrastructure issues, the adequacy of attention to safety, are exacerbated by the severe economic conditions in EE/CIS as the region shifts rapidly to market-driven

economies. Economic chaos and hardship are obvious. Demands to generate net hard currency, or minimize consumption of it, are intense. Poverty and inexperience of reactor operators during this transition period has been cited as a safety issue.

I raise these questions not as a nuclear safety phobic but instead to put these issues in context. Nuclear reactor safety issues cannot be considered in isolation from other problems facing the newly independent countries in EE/CIS.

EE/CIS NUCLEAR SAFETY IN A BROADER CONTEXT

Most Western reviews of EE/CIS reactors have been objective and professional. However, to some extent, the specific priorities and interests of Western companies and other institutions which can benefit from elaborate remediation programs, have given the efforts an odor of "ambulance-chasing." Moreover, many Western parties take the position that since the West will be supplying grants and loan guarantees to CIS/EE, then the West has the right to dictate the way the assistance money will be spent. Further, the reactor safety issues have been considered in isolation from other major problems in the CIS/EE; assessments have not addressed priorities, and relative risks, costs, and benefits of remediations proposed.

A successful assistance program for improving nuclear safety cannot be imposed; it must be carefully and realistically integrated into the economic and energy plans of each country and region. This must be done with the full cooperation of the receiving governments, ministries and power plant personnel. Assistance should also be specific to the dramatically varying needs of the individual republics. For example, it is a widely held view that the RBMK reactors are so hopelessly unsafe that only minimal assistance should be given to them. There is the mistaken belief that such pronouncements and the withholding of assistance will somehow lead to the early closure of these plants. This cannot and will not happen. This May in Karlsruhe, Minatom's Victor Sidorenko, Deputy Minister for Nuclear Energy, outlined Russia's hopes of achieving a 30-year life from its RBMK reactors. Consider the situation of Lithuania: the two 1500 MW RBMK reactors at Ignalina (the largest reactors in the world) supply greater than 50% of the country's electricity needs. With no indigenous fuel resources and an economy which can support neither the construction of alternative thermal power stations nor the importation of their fuel, Ignalina's reactors will need to remain on-line, generating electricty for many years to come. That is, they will operate with or without Western aid and assistance. The situation is similar in Bulgaria where four of the first generation VVER 440-230 reactors are operating at Kozloduy. These reactors, generally considered to be nearly as unsafe as the RBMKs, produce approximately 18% of the country's electricity. Closure would impose severe hardships on the general population. Some experts even predict that plant closures and the subsequent energy shortages, when combined with the other economic woes of the region, could even enflame civil unrest.

How then should Western governments and industry proceed?

First, it should be clearly recognized by all parties that the nuclear safety issues cannot be addressed in isolation from the other problems facing governments, at both the national and local levels. Nuclear power generation facilities (and the related infrastructure), represent major sources of electricity, heat, hard currency generation, and employment. It is imperative to let CIS/EE governments know that this dependency is recognized and understood. Aid must be given in a way to enable the recipients to help themselves over the near- and long-term, not just to alleviate certain real and imagined Western concerns about reactor safety.

Second, while recognizing the nationalism of these new republics, inter-regional cooperation in the electricity and nuclear sectors must be strongly encouraged by Western governments. Issues such as fuel manufacturing and waste management are most certainly best organized on a regional basis, utilizing the supply channels of the former Soviet Union. For example, Western governments and the nuclear industry should discourage countries considering local manufacturing of nuclear fuel which is almost certainly counter-productive to the best long-term interests of the region overall. Construction of such new facilities cannot be of real benefit when one recognizes the significant world over-capacity for nuclear fuel production.

Third, the entire energy infrastructure and electrical demand forecasts should be factored into the planned safety improvement program. This means non-nuclear as well as nuclear generation and the grid efficiencies. For example, losses in the grid run in the region about 10%. These are losses in transmitting power from generating plants to end uses. Clearly significant investment in improving the grid's efficiency could enable many regions to much more seriously contemplate closing unsafe or inefficient generation capacity. End use efficiencies should also be addressed. Future generation capacity proposed by the West should also consider com-

pleting existing plants under construction and erecting new Russian designed reactors as well as Western supplied stations such as new Combined Cycle Gas Turbines.

Fourth, address real safety issues in a prioritized manner. When estimates of suitable remediation vary from less than $1 billion USD to $40 billion USD, a bit more analysis is indicated. In a well organized turnaround program, the first dollar spent yields the most benefit, and the last dollar spent, the least. You reach an asymptote, to use some mathematic language, where further expenditures do not yield benefit, but merely result in make-work.

The foregoing comments are not intended to downplay the real need for concrete safety improvements in a number of areas across the full spectrum of nuclear power plant operations. But here again, their perspective must be taken into account. The plants have operated for a considerable time, some with availability levels the envy of many Western plants. In particular the earlier generation VVERs (PWRs) with six coolant loops and large water volumes are in some respects much more forgiving that Western designs.

Probabilistic risk assessments (PRAs) are urgently required to take these and other factors into account so that potential plant enhancements can be properly prioritized relative to their costs. However, equally important is a crash effort to define minimum safety standards in conjunction with their regulatory bodies so the PRAs can be meaningfully assessed.

Also, the West must increase its focus on the operational staff at the plants. Several recent incidents and most notably the Chernobyl disaster have stemmed directly from human errors. Increasing the concern in this respect are the continued reports from Western visitors about the very low morale of operators and the numerous distractions they must endure with today's economic circumstances. Pointing to the benefits of addressing the human factors, Lord Marshall has recently reported on the great strides achieved in Bulgaria where a program of increased pay and training for operational staff have yielded significant benefits in safe operating practice.

Finally, the West needs to give strong attention to the financing and aid strategy it is undertaking. No matter how attractive the West believes low-interest loans should be, loans to correct issues which are not considered real problems by the local government and ministry are no bargain at all. Further, Western governments should seriously consider making gifts of aid money to address operator performance and other key issues which the West considers to most significantly affect its well being. Loans should be made for the safety enhancements clearly having maximum payback in safety and efficiency based on priorities defined through the PRA studies.

In summary, the most rapid and cost-effective route to enhanced reactor safety in the CIS and Eastern Europe is by:

1. Promoting a greater dialogue with their officials and treating the nuclear safety issue in a broader perspective recognizing the other serious constraints which affect the actions of national and local officials.

2. Promoting regional based solutions and general cooperation among the governments and Nuclear Energy Ministries of the various countries.

3. Consider the nuclear safety issues in conjunction with the complete electricity industry infrastructure by considering regional supply/demand issues, export opportunities, grid improvements, new construction, and repowering options along with reactor upgrades.

4. Assist their Regulators to define minimum safety standards for both RBMKs and VVERs and then prioritize the cost benefit of potential safety upgrades with PRAs. Implement an operator support program.

5. Recognize that loans with complicated repayment schemes are not going to allow safety modifications and upgrades to take place at the pace desired by the West. Develop a plan of direct aid to fully pay for the most urgent modifications.

6. Foster CIS ability to generate hard currency, needed for reactor improvements. For example, allow the unrestrained importation of CIS uranium and uranium enrichment services.

Thank you for your attention this morning. If my company or I can be of further assistance in your review, we would be happy to cooperate.

Table 1.—Operating Reactors in CIS/EE *

Type	Bulgaria	Czechoslovakia	Lithuania	Russia	Ukraine	Hungary	Totals
RBMK			2	11	3		16
VVER–440/230	4	2		2			8
VVER–440/213		6		4	2	4	16
VVER–1000/320	2			6	10		18
Totals	6	8	2	23	15	4	58

* Excludes Fast Breeder Reactors

Prepared Statement of Gary A. Dunbar

Today, I am presenting a concept for foreign assistance with very strong strings attached. Foreign aid that is directed toward a specific goal; that will assist in resolving a major environmental problem; that will enable a republic of the former Soviet Union, Ukraine, to move aggressively toward a market economy; and that will have an accountability for performance. Many aid packages have the these attributes, but this one also comes with requirements to create jobs for Americans and to create new export markets for American products. Jobs and exports are the strings.

Jobs and exports are created by building economic and technology bridges between nations. Ukraine is now in the process of creating a nuclear regulatory system. This new Ukraine system will be modeled after the system of some western nation and thereby form a bridge between Ukraine and that nation. The system selected for emulation will create a long term market for the source nation. The program presented here could make the United States the source of the new Ukrainian system.

CREATE JOBS IN AMERICA

The concept I present to you today creates jobs for Americans. These are new jobs, providing opportunity for our highly trained professional work force, creating additional jobs through the trickle-down economic mechanism, and helping to off set the unemployment resulting from the end of the cold war. These jobs are not simply spending the taxpayers money for a one time economic boost. These jobs multiply the strength of our dollars by creating a long-tern market for the export of American scientific and engineering services. I am presenting you a concept where a small investment develops a large return.

Not only are these new jobs economically significant, they will also assist in resolving one of the planet's significant problems in energy production and maintenance of a sustainable environment. The problem these jobs address is the Chernobyl Nuclear Power Plant accident. The results achieve through the performance of this work will not only help the United States and Ukraine, it will also help the entire planet.

On July 16, just six days ago, contract negotiations were completed. The contract is now being reviewed by Vice Prime Minister Masik, the Ministry for Foreign Economic Affairs, and the Ministry of Justice. It is planned in early August that Phil Reinig, LATA's President, will sign a contract with the Government of Ukraine that lays out a ten-year program that will not only help Ukraine, but will immediately create job opportunities in the United States in nine private companies, thirty universities and colleges, and in the National Laboratories.

CREATE LONG-TERM CUSTOMERS FOR AMERICAN EXPORTS

The concept I am presenting is not limited to the creation of jobs for scientists and engineers. This concept is designed to create a strong market position for American industrial and technical products. This is a concept to increase America's exports. All countries that compete in the international marketplace have long recognized the benefits derived by providing scientific services to other countries. The provision of these services invariably creates a strong market position for the products and goods of the country that is the source of the technical services. This is not a new concept, but one that has been demonstrated countless times.

NEED FOR AID IS RECOGNIZED

Western Nations, including the United States, have recognized the importance of economic assistance to the Newly Independent States of the former Soviet Union. The recent G7 meeting in Munich provided further evidence of this international understanding. The world-wide consequences of total economic collapse in the Newly Independent States is understood and feared. As western nations grapple with the problem, an agenda of concerns has become clear—control of the weapons of mass destruction, stabilized energy resources and supply, and food production and supply. This agenda, designed to minimize the chance of war, is also necessary to build a strong future of economic interdependence.

The problem with Aid is not the recognition of the need or the development of an agenda. The problem is in the design of specific programs. Within the principals of creating jobs and export markets for Americans, we have worked with the Government of Ukraine to develop a program that will assist in the resolution of the problems created by the accident at the Chernobyl Nuclear Power Plant. Over the past six years since the accident, a great deal of work has been done by the Soviet Union, the European Community and the United States This work dwelt with emergency conditions and research. However, very little work has been undertaken to reduce the magnitude of the contamination or to reduce the dose exposure of the population. The program we have developed goes beyond research and commences an orderly procedure, based on a new regulatory structure, to remediate the damage caused by the accident.

ENERGY AND FOOD

Ukraine inherently has the wealth to become one of the world's more prosperous nations. Prior to the collapse of the Soviet system, Ukraine was an exporter of food, energy, and industrial products. Currently, 30.76 percent (or 9,295 MWe) of the operating Nuclear Power Plants of the former Soviet Union are Ukrainian. Ukraine could increase its energy production by 30.66 percent, to 12,145 MWe, if western approaches to nuclear safety can be implemented at just three existing Nuclear Power Plants.

However, in the socialist systems this export of valuable products failed to create wealth for Ukraine. If that capacity to export is revived and combined with a market economy, Ukraine should emerge as a prosperous nation. And a nation that can afford to resolve the problems created by that Chernobyl accident.

The wealth of the United States is substantially based on the same two attributes, sustained ability to export food to the world and long periods of energy independence. These attributes, combined with a healthy political and economic system, helped the United States to become an economic leader in the world. In many ways, Ukraine is like the United States—abundant resources, well educated people, sound work ethics, family oriented values, a peace loving people with a strong desire to better themselves and their nation. It should be easy for Ukraine and the United States to create bridges of mutual interest and support.

CHERNOBYL IS BLOCKING PROGRESS

Ukraine has one major stumbling block that prevents it for realizing its potential—the Chernobyl accident. Time for transition and the support of world economic institutions will bring Ukraine and the other new republics to market economies. But Ukraine will not derive the benefits of this transition as long as the shadow of Chernobyl obscures the path to the future. If Ukraine is to once again export energy, and now receive the benefits in a market economy, Chernobyl must be addressed. If Ukraine is to export food, Chernobyl must be addressed. Chernobyl is not simply a technical problem or an environmental problem, it is also a political and economic problem. Western approaches to environmental remediation and nuclear safety must be implemented and proven effective if Ukraine is to have an optimistic future

Independent States

History causes the United States and other western nations to yield a monopoly of attention to Moscow. This dominance of Moscow in the approaches of the United States to the Newly Independent States belies the new realities. Ukraine is an independent state, a new nation. Going to Moscow to address nuclear safety problems at the twenty-one Nuclear Power Plants in Ukraine will not work. The decisions that will resolve Chernobyl and create a prosperous Ukraine will be made in Kiev. The plan I am presenting is a Ukrainian plan, the result of a collaborative effort by the responsible Ukrainian Government Ministries and Los Alamos Technical associates, Inc.

FORMULA FOR FUNDING

American assistance to Ukraine should be constructed to provide benefit to Ukraine and to the United States. It is not necessary, indeed, it is foolish, to release the money of the American taxpayer to the custody of international institutions where it is used to support European efforts to build market position in the Newly Independent States. American assistance should produce real and measurable improvement in Ukraine and should produce measurable economic benefit to the United States. Achieving such mutual benefit is neither difficult nor mysterious. America's competitors readily understand the formula.

Seed Money with Strings Attached

First, seed money or grants are required to start the process. However, these grants must require that resources of United States firms be employed to executed the mission of the grant. Additionally, the grants must require a suitable in-kind match from the receiving nation.

Several objectives are achieved by these simple requirements. First, the money of the United States is used to employ citizens of the United States and a substantial portion of the money is further spent in the United States, providing additional economic benefit. More important, the work under the grant is executed using American approaches and technology, building a foundation for additional American and Ukraine interaction. Second, by requiring an in-kind match, it is assured that American and Ukrainian scientists and engineers will work together on the project funded by the grant. This builds the most important aspect of any business enterprise, mutual understanding and respect. This process will also implant the most important element of the market economy transition; management systems.

Management Systems

There is no effective way to communicate in this testimony the breadth and depth of the chasm that separates Communist and American management approaches. Only day to day personal experience can demonstrate the magnitude of this difference in approach. If Ukraine is to succeed in its transition, management approaches of a market economy must be learned. Western nations will make a tremendous error if they simply supply money to the Newly Independent States. Another string is that with grants or loans, western management systems must be employed. This will, of course, provide auditable accountability for the use of funds, a critical but minor benefit. More importantly, this string will imbed management practices that are vital for the success of the transition to a market economy. That is why the program that we present has created a management system as the first step, before funds are sought.

Sovereign Debt

Finally, Ukraine must stand on its own feet and build its own future. It is necessary that grants be structured in a program that leads Ukraine to the ability to provide the funding itself. If the export capacity of Ukraine can be revitalized then the capacity to assume long term debt is created. This will allow Ukraine to support its own programs; will enable Ukraine to purchase necessary services and goods; and will empower Ukraine to build its future. The path from grants to loans should be clear in the conditions and program of any grant. If such loans were to be provided directly to Ukraine, instead of through international institutions, then we could be assured that the services and good of the United States would be utilized.

In summary, grants have the following requirements:

- Clear objectives and plans
- Use of American resources
- In-kind matches from receiving nation
- Use of American management systems and approaches
- Clearly leads to future use of receiving nation's funds or sovereign debt.

Loans have the following requirements:

- Clear objectives and plans
- Use of American resources in collaboration with receiving nation resources

Use of American management systems and approaches.

AMERICA'S ASSETS

Why should the United States undertake this program? The economic benefits described are valuable in themselves, but there are other opportunities that are also attractive. What is there about the Chernobyl opportunity that offers a special advantage to the United States?

There are four primary assets held by the United States that are unmatched by our international competitors. Utilizing these assets will provide Ukraine with the best the world has to offer and will firmly establish an economic bridge between Ukraine and the United States.

Nuclear Science and Engineering

No other nation can match the technical prowess of the United States in nuclear science and engineering. Over the past fifty years, the national investment of the United States in nuclear energy and technology has been unmatched in its magnitude and effectiveness.

This is an asset with an uncertain future and is endanger of being lost. While this asset made the United States powerful in the cold war, it can make the United States economically strong in the new world. The technology, knowledge and skills of this asset are precisely what is needed to address the Chernobyl situation and to restore Ukraine's capacity for economic vitality.

Other nations have impressive resources to offer, but it is clear that the United States is the provider of first choice. United States industry, National Laboratories and Educational institutions are combined in this program to provide the best.

Environmental Remediation

Despite the flamboyant rhetoric of conferences and the press, the programs for protection and remediation of the environment in the United States are unsurpassed. Over the past three decades, we have spent hundreds of millions to protect and improve our environment. In this process we have created technology and knowledge resources that are unmatched. Evidence supporting this statement is the very program being presented. The Government of Ukraine has lived with the Chernobyl for over six years now; they have worked with organizations from all parts of the world; they have extensive research being conducted by the Europeans; they have interviewed and visited private firms and government institutions in many countries; and only from the United States have they received a comprehensive approach to remedy the problems of the Chernobyl accident. The reason for this is simple. Only in the United States have professional scientist and engineers undertaken and successfully implemented comprehensive environmental restoration programs.

Program and Project Management

All industrialized nations have good program and project management capabilities. There are, however, unique management issues in environmental remediation projects. From a project management view, these project are totally different from building a tower, a tunnel, a bridge or a industria complex. Environmental programs must be managed to produce results in situation with frequently changing scientific and engineering datas and criteria. Management approaches have been developed in the past decade that have proven effective for these types of programs. Again, the environmental programs of the United States are unique in their approach to project management. This is yet another special attribute that our plan presents to Ukraine.

Highly Competitive Technical Services

We have strong competitive strengths and we are the low cost provider. In business, we are positioned to win.

The program I am presenting does not exist in a passive business world, indeed, there is a great deal of competition for the Chernobyl project and the future business relations with Ukraine. What I have told you is widely know and understood. I recently attended a meeting in Kiev with Germans, British, French, and Italians. All of the firms from these nations where there to obtain work on the Chernobyl project. In addition, European financial institutions attended in order to begin to their evaluation of funding approaches. This opportunity will move from a plan to reality, with or without the United States.

Since the United States has such strong competitive assets and since the private firms of the United States cost less than the British, French and Germans it is logical for us, not just to participate, but to lead.

FRAGILITY OF INITIATIVE

There is a saying in business that windows of opportunity open slowly and shut fast. This is true of the situation with the Newly Independent States and the Chernobyl problem. The governments and citizens of these nations know that they must get on with their lives. They must make the best decision they can and proceed with

their transition to a new forms of government and economy. The opportunity presented today is short lived—it is to be acted on or it goes away.

This plan was produced by entrepreneurial initiative—a characteristic that has historically made American business strong. This initiative must now begin implementation and for that, we need the support of the United States government. Brand new programs are not required. We simply need support for the Chernobyl Plan from existing government institutions and in new legislation now being considered by Congress.

In the section that follows, I present an outline overview of the plan for Chernobyl.

CHERNOBYL COMPREHENSIVE ENVIRONMENTAL REMEDIATION PROGRAM

Introduction

MinChernobyl requires funding to establish a system to mitigate, reduce and, where possible, eliminate the consequences throughout Ukraine of the 1986 accident at the Chernobyl Nuclear Power Plant. A management and technical support team will be assembled, and preliminary plans will be developed for an integrated approach to gathering information, assembling appropriate technology, and conducting, under the direction of MinChernobyl, a comprehensive cleanup and remediation project.

On August 2, 1990, Goskomchernobyl UkSSR was established by the Supreme Soviet then converted to MinChernobyl in May of 1991 as the Ministry responsible for all Ukrainian Government actions regarding consequences of the Chernobyl accident. Since the events of Autumn 1992, including fires at the powerplant, the independence of Ukraine, and the decision of the Parliament of Ukraine to cease operations at the powerplant, responsibilities of MinChernobyl have expanded.

Mission

The main tasks of MinChernobyl are:

- To solve the entire complex of problems regarding the elimination of consequences of the Chernobyl accident, protection of the population, and coordination of research and medical institutions, state, and other establishments and organizations of Ukraine;
- To resolve financing of all scientific and technical projects;
- To conduct analyses of the scientific and technical projects and other developments;
- To control Ukrainian material and technical supply; and,
- To accomplish scientific, technical, and economic connections with other republics and organizations abroad.

Organizations at the site which formerly reported to the central government of the Soviet Union, such as "Complex Expedition" (responsible for the Sarcophagus), now report to MinChernobyl. In addition, MinChernobyl shares responsibility for decommissioning of the remaining power generating reactors.

In order to complete remediation of the consequences of the Chernobyl accident, the work has been organized into four phases which will take place over a thirty-year period. Table 1 identifies Project phases and estimated costs. This grant request is for Phase One to be approved and funded now, and for Phase Two to be reviewed, approved and funded later.

Project Management

MinChernobyl, after an extensive review of private firms in Europe and United States, selected Los Alamos Technical Associates, Inc. (LATA) as Project Manager and Systems Integrator for the entire project. LATA assembled a base team of private companies and universities to assist in the technical work. In addition, LATA secured the cooperation of Sandia National Laboratories to serve as coordinator and integrator for all US National Laboratory participation. Sandia's role will be to assess, enhance, and demonstrate where necessary, and to transfer state-of-the-art technologies to LATA for use on the project. Augmenting this US base team will be Ukrainian and other international firms. Competitive procurement for specific sub projects will be in accord with the procedures of the funding source.

The base team consists of the following organizations.

Prime Contractor

- Los Alamos Technical Associates, Inc.

Subcontractors

- Lockheed AWC
- Westinghouse SEG

- CompuChem Laboratories
- Metcalf & Eddy
- Harding Lawson Associates
- ESA
- Transmar
- New Jersey Marine Science Consortium (30 Colleges and Universities)

National Laboratories
- Sandia National Laboratory—Coordinator
- Argonne National Laboratory
- Idaho National Engineering Laboratory
- Los Alamos National Laboratory
- Lawrence Livermore National Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest Laboratory

Phase One

The Project Definition Phase, consists of six tasks:

1. Establishment of a Financial Mechanism to generate funds for paying for the execution of the full Project.

2. Development of a Preliminary Program Plan for the Project.

3. Compilation of the information necessary to replace lost power generation capacity and decommission Chernobyl reactors 1, 2, and 3.

4. Compilation of the information necessary to determine a permanent resolution for the destroyed Chernobyl reactor 4 and the "Sarcophagus."

5. Preliminary training to foster the establishment of private competitive Ukrainian firms.

6. International food conference to identify potential approaches to supply milk and meat to 2.6 million people living in contaminated areas.

Phases are primarily defined by the nature of work to be done. Phases will overlap in time, depending upon the specific requirements and urgency of the work. Funding for each phase may come from: a) grants or gifts; b) MinChernobyl operational funds, including funds from the Commonwealth; and, c) debt financing.

Table 1.—Cost Estimate

Item	Ukraine Cost	Foreign Cost	Comment
Phase One—Project Definition Total—Year One	**US $705,000**	**US $3,500,000**	**Grant Required Total Cost Estimate US $4,205,000**
Financial Mechanism	US $20,000	US $100,000	Grant Required
Program Definition	US $120,000	US $700,000	Grant Required
Replacement Power & Decommissioning	US $200,000	US $1,500,000	Grant Required
Reactor 4 Site (Sarcophagus)	US $165,000	US $500,000	Grant Required
Training	US $100,000	US $500,000	Grant Required
Food Conference	US $100,000	US $400,000	Grant Required
Phase Two—Comprehensive Plan Total—Year One	**US $4,000,000 Preliminary Cost Estimate**	**US $16,000,000 Preliminary Cost Estimate**	**Grant Required Total Preliminary Cost Estimate US $20,000,000**
Reactors 1, 2, & 3 D&D	US $1,000,000	US $3,000,000	
Reactor 4 Site	US $800,000	US $1,500,000	
Contamination Migration	US $150,000	US $2,100,000	

Table 1.—Cost Estimate—Continued

Item	Ukraine Cost	Foreign Cost	Comment
Agriculture & Food	US $100,000	US $1,400,000	
Water	US $100,000	US $400,000	
Soils	US $500,000	US $2,200,000	
Waste Management	US $600,000	US $2,900,000	
Health	US $750,000	US $2,300,000	
Phase Three—Mobilization, Site Investigation and Feasibility Studies	**US $60,000,000**	**US $270,000,000**	**Combination of Grants, Operational Funds and Debt Financing**
Total—Years One through Four			**Total Preliminary Cost Estimate US $330,000,000**
Year One	US $10,000,000	US $30,000,000	
Year Two	US $20,000,000	US $95,000,000	
Year Three	US $20,000,000	US $95,000,000	
Year Four	US $10,000,000	US $50,000,000	
Phase Four—Operational Funds and Remediation and Construction	**To be determined**	**To be determined**	**Operational funds and Debt Financing**
Total—Years Two through Thirty			**Total Cost Estimate To Be Determined**

ACUTE AND CHRONIC PROBLEMS

The Chernobyl accident has created both acute and chronic problems for Ukraine and its neighbors. These problems may be summarized as three broad categories for the purpose of general discussions of the "Chernobyl problem". Situations that are 1) acute threats or hazards to Ukraine and its neighbors, 2) chronic problems for Ukraine, and 3) chronic problems caused by the accident, combined with the changes in government and economy are described below.

Situations with a Potential Threat or Hazard to Ukraine and Other Nations

SARCOPHAGUS

The "sarcophagus" that encloses the destroyed Chernobyl unit 4 was hastily built after the accident under urgent conditions. The resulting structure does not provide the desired containment and protection against the further spread of radioactive material through the atmosphere and waterways within Ukraine and across national boundaries. Existing concerns are settling of the ground beneath the structure, large openings in the structure, and problems of maintenance.

Recently, Soviet experts determined that the Sarcophagus could not be relied upon beyond five years and that the Sarcophagus should be replaced or other remedial action taken soon.

A permanent technical resolution for the Sarcophagus must be determined, engineered, designed, and implemented. Meanwhile, interim safety measures are needed to extend the lifetime of the sarcophagus until a permanent resolution can be implemented.

Decommissioning the Power Plant

A decision has been made that further operation of all units at the Chernobyl nuclear Power Plant will be terminated, the units decommissioned, and appropriate remedial actions taken. Specific plans must be developed rapidly to shut down the plant, remove and dispose of fuel, decommission the facilities associated with the operation of Chernobyl units 1, 2, and 3, and to take remedial actions concerning radioactive contamination associated with these units.

Contamination Migration

The accident in 1986 created a large contaminated area in Russia, Byelorussia and Ukraine as contaminated materials were distributed to a large area by atmospheric winds. Over the past five years, contaminated materials have continued to move, carried by winds, water currents, insects, and animals without respect for national boundaries. Migration of this contamination must be better understood and actions must be identified and implemented to stop this movement. Ultimately, the contaminated area must be reduced.

Situations Which Create Chronic Problems Within Ukraine

Food Supply

The radiation dose contribution to individuals and to the general population from the production, processing, and distribution and consumption of food must be kept within acceptable limits.

Water

Water is a concern because it is consumed by the population and because water transports contamination to other locations. The specific concern within Ukraine is the long-term supply of contamination-free potable water.

Soils

Contaminated soil not only impacts food production, it also provides material that can become re-suspended in the atmosphere and thereby spread contamination. Highly contaminated areas must be identified, mapped, and cleaned up.

Waste Management and Decontamination

Operations, facilities and equipment must be developed and deployed to collect contaminated material, retrieve temporarily stored contaminated material, and decontaminate materials, equipment and structures, and build repositories, and transport and dispose of contaminated waste and materials.

Health Care

Much of the effort since the accident in 1986 has focused on the health of the population. This effort must continue for several generations. The necessary work includes epidemiological studies of the general population, as well as decontamination of workers; episodic, emergency and short-term health care; and, a documentation and archival system. In addition, health care facilities, medications and other supplies are needed.

Population Care

The physical, social and psychological welfare of the population impacted by the Chernobyl accident is a complex and long-term problem area. Efforts made on behalf of the population include everything from housing to relocation to individual counseling.

Institutional Infrastructure Need

Planning and Management

A comprehensive plan for cleanup of the contamination and other problems created by the accident does not now exist. One of the most pressing needs of MinChernobyl is to develop a comprehensive plan which coordinates all research, cleanup, decontamination, health care and institutional infrastructure development, and a plan which is credible in the international community.

Financial

Financial infrastructure needs to include a) establishment of a mechanism that will provide sufficient, long-term funding from Ukraine resources; b) development of financial management systems and accounting practices that will assure responsible control of funds; and, c) obtaining funds to bridge the change in government structure from the central government to the independent government of Ukraine.

Nuclear Materials Management

Ukraine requires development of an infrastructure of standards, regulations and government offices to oversee and control the production, transportation, use, and ultimate disposal of nuclear material and waste.

Program and Project Management

Goal oriented program and project management techniques that are common in some nations must be adopted and developed in Ukraine to assure that stated objectives are actually accomplished.

Training

Training of Ukrainians in technology, management and business practices is required for MinChernobyl to fulfill its mission in the new government of Ukraine and in its market economy.

Organization—Work Organization Concepts

The work organization for part of Phase One, and all of Phases Two, Three and Four is subdivided into four major elements based on the nature of the work to be performed. These four elements are:

1. Business Operations and Management
2. Technical Support
3. Operations
4. Technology Assessment, Enhancement, and Transfer Business Operations and Management

This element contains those functions that support Project Management and are necessary to achieve the success of the technical work. These include the following Management Areas:

1.1 Standards and Compliance
1.2 Liaison
1.3 Finance and Administration

Technical Support

The Technical Support element is comprised of functions that directly support the technical projects. Economy is achieved by combining these functions into a centralized support element. Such centralization also facilitates progress monitoring, quality control, and credibility of the results. The Management Areas for the Support element are:

2.1 Data Management
2.2 Technical Services
2.3 Training Program

Operations

The Operations element is divided into nine Project Areas for performance of the actual scientific, engineering, field, and construction work required to remediate the contamination from the Chernobyl Power Plant accident. The nine areas are defined based on environmental and physical systems that are contaminated. This approach groups technologies and activities into similar and related disciplines, and will enhance the effectiveness of the total remediation work by facilitating execution of a comprehensive, integrated plan for remediation. The nine Project Areas are:

3.1 Decommissioning and Decontamination of Power Plant
3.2 Reactor 4 Site
3.3 Contamination Migration
3.4 Agriculture and Food
3.5 Water
3.6 Soils
3.7 Waste Management
3.8 Health
3.9 Population Care

Technology Assessment, Enhancement, and Transfer

The objective of the technology assessment, enhancement, and transfer element is to provide for the use of advanced, state-of-the-art technologies existing at US National Laboratories in all phases of the project. Individuals from the US National Laboratories will participate in all planning activities for performing the actual scientific, engineering, field, and construction work required to remediate the contamination from the Chernobyl Power Plant Accident. System engineering and integration methodologies will be used to prioritize remedial actions, identify advanced

technologies, and perform trade-off analyses of candidate processes. Six areas are defined based on a systems engineering approach, and these areas will be matrixed into all other work areas. This approach groups technologies and expertise into a system framework that incorporates all related disciplines and enhances the effectiveness of the remediation effort.

Specific activities that Sandia National Laboratories will pursue include the following:

1. Coordination and integration of all US National Laboratory participation.
2. Site characterization
3. Systems analysis
4. Hazardous materials characterization, immobilization, confinement and containment
5. Performance and risk assessment
6. Earth and atmospheric science
7. Waste transportation and management
8. Hazardous materials monitoring, cleanup, handling, packaging, storage, and disposal
9. Environmental restoration

The six Project Areas are:

4.1 Database Development
4.2 Preliminary Hazard Assessment
4.3 Remediation Objectives
4.4 Systems Analysis
4.5 Systems Enhancement and Demonstration
4.6 Technology Transfer

PHASE ONE

Project Definition—Scope of Work

TASK ONE—FINANCIAL MECHANISM

The Mission of MinChernobyl and the Chernobyl Accident Contamination Remediation Project can be achieved only if long-term, consistent funding is assured. To provide this assurance, it is necessary to establish a government/industry mechanism or institutional infrastructure that will provide a dependable source of revenue. With a source of revenue in place, MinChernobyl will then be able to plan multi-year programs, select cost effective actions, prioritize activities to achieve the greatest result, and consider debt financing approaches.

MinChernobyl has embarked on preliminary efforts to explore feasible approaches and the steps necessary to implement a financial support mechanism. Assisted by Los Alamos Technical Associates, Inc. (LATA), MinChernobyl has met with World Bank, EXIM BANK, Overseas Private Investment Corporation, and European Bank for Reconstruction and Development. In addition, preliminary exploration of the necessary changes to Ukraine law have begun.

SUB-TASKS

1. Conduct program definition discussions and make findings in Ukraine and the United States to determine the parameters for various import/export transactions, requirements for laws facilitating international work on Chernobyl, and needed infrastructure support. This work will involve representatives from LATA, meeting with Ukraine officials in Ukraine and in the United States.
2. Prepare draft laws and regulations necessary to support the financial mechanism in Ukraine. This work will involve review of Ukrainian laws and regulations regarding trade and taxation, as well as international agreements which may apply to Ukraine and to the Chernobyl project.

DELIVERABLES

1. Overview report on institutional infrastructure support required for long-term financial support of Ukraine Chernobyl Accident Contamination Remediation Project.
2. Draft laws and regulations to support Chernobyl Accident Contamination Remediation Project.

SCHEDULE

Week One—Notification of Award of Grant
Weeks Two, Three and Four—Mobilization and meetings with parties in the United States
Weeks Five and Six—Meetings in Europe and Ukraine regarding Institutional requirements

Weeks Seven and Eight—Preliminary report preparation and begin draft of laws and regulations

Weeks Nine and Ten Ukraine—Delegation in United States for coordination reviews and technology evaluations

Weeks Eleven and Twelve—Meetings in Ukraine and Europe.

Weeks Thirteen, Fourteen and Fifteen—Final report preparation and draft of laws and regulations.

EQUIPMENT

Two notebook computers and portable printer.

COST

The total cost of Task One is estimated at US $120,000.

TASK TWO PROJECT DEFINITION—PRELIMINARY PROGRAM PLAN

The consequences of the accident at the Chernobyl Nuclear Power Plant are an immense, complex, and multifaceted social/technical/health problem. The resolution of this problem can only be achieved by successful implementation of many small, well thought out, and purposeful steps which are all orchestrated to achieve one goal: the elimination of these consequences. The implementation of these small steps requires a plan.

The plan for Chernobyl must integrate a wide multi-disciplinary effort into a force working for a common goal. To develop this plan, the first step is collection, organization, and dissemination of existing information. This task is defined to compile this baseline information.

SUB-TASKS

1. Collect available data and documentation concerning current and recent conditions at the Chernobyl site regarding:

1.1 Migration or transport of radioactive contamination, including

a. Atmospheric transport of radioactive contamination,

b. Potential sites or conditions where re-suspension of radioactive contamination occurs or is likely to occur,

c. Actions taken or under consideration to prevent or reduce atmospheric transport or migration of contamination,

d. Extent of radioactive contamination of water, silts and sediments,

e. Surface water and groundwater transport of radioactive contamination,

f. Chemical and physical interaction of radioactive contaminated particles and material with the environment,

g. Meteorological data and phenomena relative to atmospheric and water transport of contamination,

1.2 Agriculture, food and biota, including

a. Biota in the affected areas and their contribution to population dose,

b. Food chain and population diet patterns

c. Food processing, inspection and distribution

d. Biota transport of radioactive contamination,

e. Actions taken or under consideration to prevent or reduce contamination of population food supply,

1.3 Potable water supply, including

a. Potential for radioactive contamination of potable water and water supply system,

b. Existing water treatment and distribution system,

c. Actions taken or under consideration to prevent or reduce contamination of population water supply,

1.4 Soils, including

a. Radioactive contamination of soils, including extent, nature of contaminate, depth in soil of contamination,

b. Types of soils including physical and chemical data,

c. Techniques used to assess hazard of areas of contaminated soil,

d. Actions taken or under consideration to prevent or reduce contamination of soil,

1.5 Waste management, including

a. Sampling and analysis of waste materials,

b. Number, location and extent of burial sites,

c. Actions taken or under consideration to decontaminate materials, equipment, facilities or communities,

d. Technologies currently used for decontamination activities,

e. Techniques for management and control of contaminated waste generated by decontamination activity,
f. Number, location, extent and physical characteristics of disposal facilities or repositories for radioactive waste,
g. Methods of transportation, handling and packaging of radioactive waste,
h. methods of waste treatment and disposal,
i. Documentation processes for radioactive waste management,
1.6 Health Care in the affected area, including
a. Epidemiological studies completed and in progress,
b. Health care facilities, staffing, equipment and supplies, and
1.7 Population Care, including
a. Condition of resettlement areas, including transportation infrastructure, human habitat, employment, energy supply, water supply and sewage treatment, and social support amenities,
b. Construction capability, including supply production of building materials and on-site capabilities.
2. Selected representative documents will be translated to English.
3. Establish three information centers by:
3.1 Supplying IAEA with copies of representative selections of collected data and documents,
3.2 Creating and organizing an information center at MinChernobyl's office in Kiev, and
3.3 Creating and organizing an information center in Boston, Massachusetts in the United States.

DELIVERABLES

1. Program Plan baseline report containing a synopsis of existing information, directory of persons and institutions with relevant information or resources, identification of data needs and specifications for quality of data required, and presentation of any alternatives currently identified for the approaches to specific situations regarding:
a. Standards and Compliance
b. Data Management
c. Field instrumentation
d. Analytical and radiological laboratory
e. Radiation Safety
f. Meteorology
g. Training
h. Contamination Migration
i. Agriculture and Food
j. Potable Water Supply
k. Contaminated Soils
l. Waste Management
m. Population Care
n. Information collected in tasks three and four below
2. Detailed work plan for the collection of additional required data, identification of specific projects, establishing procedures for determining cost/benefit tradeoffs, identification of schedule and funding limitations or parameters, as necessary for development of an integrated comprehensive plan for addressing the consequences of the accident at the Chernobyl Nuclear Power Plant. The work plan shall also present a schedule for completion of the comprehensive plan and cost estimate for the work.

Schedule

Week One—Notification of Award of Grant
Weeks Two through Six—Mobilization
Weeks Six through Twenty—Data and document collection in Ukraine and Russia, including interviews with key persons and translation of representative documents
Weeks Twenty through Twenty-six—Preliminary report preparation
Weeks Twenty-six through Thirty-two—Establish information centers
Weeks Thirty-two through Thirty-eight—Final report preparation.

EQUIPMENT REQUIRED

Ten portable computers with software and portable printers .
Six desk top computers with software and laser printers.
Five portable copy machines.
Four high volume stationary copy machines.

Four sets dictation and transcribing equipment.

COST

The total cost of Task Two is estimated at US $820,000.

TASK THREE PROJECT DEFINITION—REPLACEMENT POWER AND REACTORS 1, 2, AND 3 DECOMMISSIONING

There were four 1000 MWe powerplants operating at Chernobyl in 1986, with two additional powerplants under construction. Explosions and fires destroyed the reactor of Unit #4 in 1986, and fires destroyed the generators of Unit #2 in 1991. Construction of Units #5 and #6 was suspended after the 1986 accident. It is the intention of Ukraine to shut down all of the remaining RBMK Model 1000 nuclear reactors. Most of the infrastructure, some of which is radioactively contaminated, for the production and distribution of approximately 5000 MWe of electric power still exists at the Chernobyl Nuclear Power Station.

Ukraine needs more electric power, both for internal economic growth and for export to gain "hard" currency. In order to accomplish its mission of remediating the effects of the Chernobyl Accident, MinChernobyl and UAEP need to know whether significant electrical generating and distributing capacity can be reclaimed at the Chernobyl Station. MinChernobyl and UAEP also need to know whether significant increases can be obtained in generating capacity of other Ukrainian (nuclear and non-nuclear) electrical generating stations through upgrades in equipment and controls and efficiency of operation

In order to proceed logically and safely with replacement power and the decommissioning of the reactors, it will be necessary to collect and evaluate existing data regarding the present configuration of the reactors, their operating history, fuel loading and burn-up, and the procedures which are followed during reactor operation.

SUB-TASKS

1. Collect available data and documentation concerning current and recent conditions at the Chernobyl site regarding:
1.1 Present configuration of the three reactors,
1.2 Operating history of the reactors,
1.3 Fuel loading and burn-up,
1.4 Existing operating procedures, and
1.5 Existing fuel and material disposal practices and facilities,
2. Collect available data and documentation concerning replacement power supply requirements and options.
2.1 Condition of the power grid and other support facilities at the Chernobyl site,
2.2 Condition of the partially completed power generation stations,
2.3 Condition of generation facilities at blocks 1, 2, and 3, and
2.4 Market potential for export of electricity to European states.
3. Selected representative documents will be translated to English.
4. Requirements for Decommissioning Plan Report
5. Feasibility of replacement Power Report

DELIVERABLES

1. Decommissioning Plan Report

Operating reactors 1, 2, and 3 baseline report containing a synopsis of existing information, directory of persons and institutions with relevant information or resources, identification of data needs and specifications for quality of data required, and presentation of alternatives currently identified for the long term shutdown and decontamination of the reactors and adjunct facilities.

2. Feasibility of Replacement Power Report

Replacement Power Supply baseline report containing a synopsis of existing information, directory of persons and institutions with relevant information or resources, identification of data needs and specifications for quality of data, and presentation of alternatives currently identified for making up the power supply lost by the accident and decommissioning of the Chernobyl Power Stations reactors.

SCHEDULE

Week One—Notification of Award of Grant
Weeks Two through Six—Mobilization
Weeks Six through Twenty—Data and document collection in Ukraine and Russia, including interviews with keys persons and translations of representative documents
Weeks twenty-one through twenty-four—Report preparation

EQUIPMENT REQUIRED

Four notebook computers with software and two portable printers .
One set dictation and transcribing equipment.
(Note: Equipment will be left in the custody of MinChernobyl for use on the Chernobyl project and will be temporarily available to future delegations from the United States.)

COST

The total cost of Task Three is estimated at US $1,700,000.

TASK FOUR PROJECT DEFINITION—REACTOR 4 SITE

MinChernobyl has decided that an international competition is the appropriate approach to determining the ultimate disposition of Reactor 4 Site (sarcophagus). In addition to the long term concerns at the site, there are also requirements for maintenance and expedited measures to address urgent and threatening hazard conditions. To respond to either of these objectives it is necessary to compile basic information on the existing conditions or a baseline data report and determine the criteria for long term resolution of the site.

SUB-TASKS

1. Collect available data and documentation concerning current and recent conditions at the Chernobyl Reactor 4 Site regarding:
1.1 Present configuration of destroyed reactor 4,
1.2 Present configuration and condition of the containment structure know as the sarcophagus,
1.3 Present maintenance operations at the site,
1.4 Identified conditions requiring urgent actions to reduce threat of additional radioactive contamination release, and
1.5 Present condition, configuration and operation of support facilities.
2. Selected representative documents will be translated to English.
3. Prepare reports.

DELIVERABLES

1. Reactor 4 Site baseline report containing a synopsis of existing information, directory of persons and institutions with relevant information or resources, identification of data needs and specifications for quality of data required, and presentation of any alternatives currently identified for the long-term disposition of the "sarcophagus".
2. Detailed work plan for the collection of additional required data, identification and evaluation of alternatives, and competitive procedure to be used to select an alternative for implementation. Work plan shall also present a schedule and cost estimate for the work.

SCHEDULE

Week One—Notification of Award of Grant
Weeks Two through Six—Mobilization
Weeks Six through Fifteen—Data and document collection in Ukraine and Russia, including interviews with key persons and translation of representative documents
Weeks Fifteen through Twenty—Report preparation

EQUIPMENT REQUIRED

Two portable computers with software and portable printers .
One set dictation and transcribing equipment.

COST

The total cost of Task Three is estimated at US $665,000.

TASK FIVE—PRELIMINARY TRAINING

The Chernobyl project, costing hundreds of millions of dollars and spanning twenty to thirty years, pragmatically requires that most of the technical, scientific and construction work be performed by Ukrainians. The transition to a market form of economy, intrinsically, requires that private Ukrainian firms be created who can compete for this work. These two requirements are emphasized by the planned use of funds from international banking organizations (World Bank, et al) who further require competitive procurement practices.

Many private companies have been formed in Ukraine. However, while entrepreneurial, they lack the specific, practical knowledge of how to operate successfully in competitive marketplace. This preliminary training will provide a core group of

Ukrainian entrepreneurs with the practical, real-world knowledge to operate successful technical service companies in a competitive world.

For the Chernobyl project, specific types of companies will be required; Technical Service Companies. These are companies offering engineering, scientific and construction services in areas such as:

- Construction (New Shelter or "Sarcophagus" for damaged Block four, water treatment facilities, earth moving and materials handling for soils decontamination, food processing facility construction),
- Remedial investigation and feasibility studies (sample collection, contamination computer modeling, identification and evaluation of remediation technology),
- Design (engineering plans, specifications and bid documents for remediation projects), and
- Project Management (Critical Path Scheduling, Earned Value Management, etc)

The training will combine academic and practitioner trainers from the United States with specialized trainers from Ukraine. The training will be conducted under the auspices of MinChernobyl. The content will include:

- How to start a Technical Services Company (Business Plan),
- Who are the clients or customers (Ukraine government as a client),
- Economics of a Technical Services Company (flow of funds, key indicators, etc.),
- Management Information Systems (MIS) for a Technical Services Company,
- Critical Path Method (CPM) scheduling for projects,
- Project Management,
- Marketing,
- Preparing successful proposals,
- Cost estimating,
- Legal requirements in Ukraine (Ukrainian Trainer)

Sub Tasks

1. Develop detailed training plan and course materials.
1.1 Develop final curriculum
1.2 Develop course materials and handouts
1.3 Develop computer based training aides for Economics, MIS, CPM, etc.
1.4 Assembling video materials
1.5 Translation
2. Training in Kiev.
3. Evaluation of training report
4.1 Evaluation of training by trainees
4.2 Evaluation by MinChernobyl
4.3 Identification of needed improvements for future training

Deliverables

1. Trainer's Manual—20 copies
2. Student Course Book—40 copies
3. Training Evaluation Report

Schedule

Week One—Notification of Award of Grant
Weeks Two through Four—Mobilization of Training Team
Weeks Five Through Nine—Preparation of Trainer's Manual and Student Course Book's
Week Ten—Training Team review and travel preparation
Weeks Eleven through Sixteen—Training in Kiev
Weeks Seventeen through Eighteen—Prepare Evaluation Report

Equipment Required

Six Desk Top Computers with software, network and one printer.
Computer projection device
Overhead Projector
Electrical conversion devices
Miscellaneous supplies (easel, flip charts, markers, tape, notebooks, paper, etc.)
(Note: All equipment will be left in the custody of MinChernobyl at the end of the training and will be available for future training courses)

Cost

The total cost of Task Five is estimated at US $600,000.

Task Six—Food Conference

The contaminated land area in Ukraine has a population of 2,600,000 people. A significant path of radiation exposure is the consumption of milk and meat. The

total dosage through food, milk and meat constitutes 80 percent of the total dosage exposure. There are two conceptual solutions to this problem; change the food of cattle and dairy cows to a non-contaminated material and/or bring milk and meat from non-contaminated areas to the towns and villages in the contaminated area. While these concepts are easy to grasp, there are many practical considerations and details to be resolved before an actual plan can be developed and implemented.

The objective of the Food Conference is to identify specific, feasible approaches to the supply of milk and meat for the 2,600,000 people. With specific approaches identified, follow on work can develop detailed implementation plans, arrange for funding, possibly attract investment capital, and implement projects to resolve this problem.

The Food Conference will involve a cross section of Ukrainian government institutional representatives, United States government, academic and business representatives and specialists in the total Chernobyl problem. A small core group of these will be specially prepared with knowledge of Ukrainian conditions and culture as well as United States potential technologies and management approaches. The actual conference will consist of presentation of papers and problem solving workshops.

Since part of the objective is to attract potential investment capital, representatives from the United States food industry will be invited to attend. To encourage this attendance, the conference will be held in the United States.

SUB-TASKS

1. Ukraine delegation visit to United States

1.1 Arrange itinerary for visits to dairy and meat processing facilities, food distribution facilities, food industry companies, and academic institutions.

1.2 Delegation visit

1.3 Delegation report

2. United States Delegation visit to Ukraine

2.1 Arrange itinerary for visit to typical affected towns and villages, food processing facilities, food distribution facilities and related institutions.

2.2 Delegation visits

2.3 Delegation report

3. Food Conference

4. Report

DELIVERABLES

1. Ukraine Delegation Report
2. United States Delegation Report
3. Food Conference Report

SCHEDULE

Week One—Notification of Award of Grant

Week Two through Five—Mobilization of Ukrainian and United States Delegations

Weeks Six through Eight—Ukraine Delegation visits United States

Weeks Nine and Ten—Return of Ukraine Delegation and departure of United States Delegation and preparation of Ukraine Delegation Report

Weeks Eleven through Thirteen—United States Delegation visits Ukraine and preparation of United States Delegation report

Weeks Fourteen and Fifteen—Food Conference

Weeks Sixteen through Eighteen—Prepare Food Conference Report

EQUIPMENT REQUIRED

Two Notebook computers, software, and portable printer.

Video camera and supplies

COST

The total cost of Task Six is estimated at US $ 500,000.

PHASE TWO

Comprehensive Planning—Concept Outline

The Work Plan is divided into four project elements: Business Operations and Management, Technical Support, Operations, and Technology Assessment, Enhancement, and Transfer. The Business Operations and Management and Technical Support elements, in turn, are divided into Management Areas; the Operations element into Project Areas. A brief overview of each Management and Project Area is followed by a more detailed discussion of Sub-areas, with emphasis on the objectives to

be achieved during the first phase. Ten weeks will be devoted to Mobilization (the gathering of project resources); this will be followed by a twelve-week period of Full Project Planning in the Ukraine, and then by a six-week period for the consolidation of the detailed area and Sub-area descriptions into a Comprehensive Integrated Plan.

In each Management and Project Area, Phase Two sets forth the immediate actions to be undertaken as soon as project funds are available. Many of these actions will be administrative and thus generic—that is, common to several or all areas and sub-areas. These common actions are set forth at the end of the Work Plan and incorporated by reference in the detailed write-ups. Immediate actions that are specific to individual Management and Project areas are listed for each area under Phase Two, which is described at the end of this section.

DESCRIPTION OF THE WORK TO BE PERFORMED

Project and management areas will accomplish certain immediate actions to be initiated as soon as possible after notice to proceed. Actions will be performed by each area for mobilization, full project planning, and development of a comprehensive integrated plan. Mobilization actions will be accomplished in the first 10 weeks of the project; full project planning will be accomplished during the following 12 weeks in the Ukraine and other international locations; and, the comprehensive integrated plan will be prepared as the final step. Each project and management area described in the project work plan will perform the following actions:

MOBILIZATION

Foreign Preparations

- Complete Service and Equipment contracts
- Identify data requirements for planning
- Determine and assemble equipment and supplies

Technology Evaluation Visit

- Prepare for and host representatives of MinChernobyl to international facilities for the purpose of evaluating potential technology and capabilities

Kiev Preparations

- Arrange for passports, visas, and immunizations
- Conduct medical screening and make travel and communication arrangements
- Arrange for provision of offices, housing, food, local transportation and other personnel support for Full Project Planning team

FULL PROJECT PLANNING

Conduct an overview/orientation visit to critical and representative areas to include the Ukraine and other selected areas

Identify and establish contact with Ukrainian technical and management representatives

Visit selected institutions and agencies to determine availability of pertinent data (to include international organizations)

Obtain copies of applicable studies, research reports and other documents, and arrange for translations

Conduct initial assessments of adequacy of available data

Establish requirements for additional information and data acquisition

Develop scope of work for full project execution, including scheduling, staffing requirements, coordination with other sub-areas and sub-projects, and support requirements

Identify and schedule the phase-in of subcontractors for specific sub-areas and sub-projects, as appropriate

Develop Authorization Request Work Plan for Phase three.

Comprehensive Integrated Plan

Coordinate with other project areas to develop interfaces and to ensure joint utilization of facilities and staff.

Identify and resolve conflicts and eliminate gaps in planning.

Combine development and utilization of Ukrainian affiliates and sources.

Prepare Comprehensive Integrated Project Plan with description of the work, critical path schedule, and order-of-magnitude cost estimate.

DELIVERABLES

The deliverables for the immediate action phase of the project are:

Deliverable 1—Authorization Request Work Plan for Task 2 for each appropriate Sub-project

Deliverable 2—Full Project Plan documents for each sub-project that describe detailed activities to be performed, schedules, and cost estimates for work to be performed beyond Phase Two

Deliverable 3—Comprehensive Integrated Plan document that integrates the Full Project Plans from each sub-project into a single plan for work to be performed beyond Phase Two and includes detailed work descriptions, schedules, and cost estimates.

SCHEDULE

Mobilization—Ten weeks to complete all work from the date the Notice to Proceed is received.

Full Project Planning—Twelve weeks to complete all work from the date Mobilization is complete.

Comprehensive Integrated Plan—Six weeks to complete all work from the date Full Project Planning is complete.

WORK AREAS

The Management areas encompass Business Operations and Management and Technical Support elements to provide centralized control and coordination, uniform communication with outside entities, timely and cost-effective response to contract requirements, and economical mechanisms for project-wide support.

1.0 BUSINESS OPERATIONS AND MANAGEMENT AREAS

Business Operations and Management Area 1.1—Standards and Compliance

This management area will provide project-wide coordination and staff supervision of project activities related to standard setting and compliance, environmental evaluations, and quality assurance and control. Included in this management area is the development and maintenance of dose models and dose assessments for various conditions and options. These, in turn, are used for determining where remedial actions are required and for evaluating the effectiveness of remediation options. Because health and safety standards and practices are vital to the well-being of the project participants, this function is included in Management Area 1.

SUB-AREAS

1.1.1 Guidelines for Remedial Actions

Applicable laws, standards and protection guides will be studied and interpretations developed for use throughout the program in recommending site-specific guidelines for remedial actions. These guidelines will be presented as recommendations by a contractor for MinChernobyl approval and, when approved, will be interpreted for and applied to remediation activities.

1.1.2 Dose Assessment

A master data base will be established and maintained throughout the project. Pre-existing radiological data will be collected and verified where possible, and additional data will be collected continuously from all project and sub-project areas. Models will be constructed to facilitate the estimation and prediction of human dose in all demographic groups. Dose assessments will be prepared for all affected sites under existing radiological conditions and under conditions expected to exist following postulated remediation actions. Post-remediation dose assessments will be made and entered into permanent program documentation.

1.1.3 Health and Safety

This sub-area will provide coordination and staff supervision of all activities related to the health and safety of project participants. Its major divisions will be medical, industrial, and health physics. A small service group under this sub-area will provide preventive health services, limited primary care, referrals, and coordination of medical evacuations as required. The industrial safety component will be charged primarily with job-site safety in field activities, assisting subcontractors with safety planning and implementation. The health physics component will advise and assist operations project areas and other staff and support elements as required in the preparation of radiation safety plans and will conduct field inspections and audits to ensure that accepted radiation safety practices are being followed.

1.1.4 Environmental Evaluation

This sub-area includes coordination with Ukrainian authorities and others as appropriate to determine requirements for environmental documentation pertaining to all phases of field work. Formats and procedures will be established for submission of information and plans by sub-projects, including proposed environmental protec-

tion measures. As required, these plans will be submitted to appropriate Ukrainian officials for approval.

1.1.5 Quality Assurance

The quality assurance (QA) sub-area includes the establishment of quality assurance requirements for all project areas and for selected management sub-areas. QA plans will be developed at these project and sub-area levels, reviewed by the QA staff, and incorporated in an overall cleanup project QA plan. Audit and follow-up will be performed at all stages and fully documented.

Business Operations and Management Area 1.2—Liaison

This management area provides points of contact, coordination, and liaison with a variety of outside entities. In Ukraine, this will include both government and private groups and the media. Elsewhere in the international arena, it will include other republics and the All-Union Academy of Sciences, as well as such international agencies as the International Atomic Energy Agency (IAEA), the World Bank, and others as appropriate. In the United States, it will include such agencies as the Overseas Private Investment Corporation (OPIC) and the Agency for International Development (AID), as well as government agencies concerned with technology transfer and treaty-related exchanges. Project-related visits by Ukrainian government officials will be coordinated by liaison staff.

SUB-AREAS

1.2.1 Technical Liaison

Assistance will be provided to project area and data management staff in opening channels for the exchange of project information and technical data, especially pertaining to Chernobyl accident-related activities in the other affected republics. Coordination will be established for the exchange of information and data with the IAEA and with the Nuclear Energy Agency (Europe) and the All-Union Academy of Sciences. Close coordination will be maintained with the U.S. Government agencies concerned with technology transfer and with U.S. obligations and constraints under international treaties and agreements. Such agencies will be kept fully and currently informed of appropriate portions of project plans, and their assistance will be sought in timely resolution of issues. Contact will be maintained with funding and loan guarantee agencies and others as potential sources of financial support.

1.2.2 Client and Community Relations

A concerted effort will be made throughout the project to establish and maintain credibility with the population. All information bearing on public health and safety will be openly published and explained. Schools, community groups, and the media will be encouraged to observe and comment. An initial technology transfer visit of Ukrainian officials to project-related international facilities will be coordinated, as will any subsequent project-related visits.

Business Operations and Management Area 1.3—Finance and Administration

SUB-AREAS

1.3.1 Project Finance

This sub-area will oversee the finance activity for the entire project. The work will involve control of budget forecasting and maintenance, financial and transactional operations, and export financing development.

1.3.2 Logistics and Procurement

This sub-area will provide staff support to the overall project management contract as well as the subcontracts with international and Ukrainian firms. It will oversee, draft, review, and finalize all procedures and contracts involving competitive procurement of goods, services, and equipment. It will make all necessary preparations and arrangements for transportation, accommodations and meals for all employees, contractors, and agents of the project while they are in the Ukraine.

1.3.3 Legal

This sub-area will provide staff guidance in all legal matters and will oversee, coordinate and provide liaison with outside counsel in matters related to the project.

1.3.4 Management Information System

This sub-area will oversee the specification, acquisition, implementation, and operations of the financial and project management information systems.

1.3.5 Management Assistance

This sub-area will have general responsibility for the management assistance portion of this project. Included will be assistance to the Ukrainian Representative and

MinChernobyl in both technical and project management and commercial and finance management and planning.

2.0 TECHNICAL SUPPORT MANAGEMENT AREAS

Support Management Area 2.1—Data Management

This management area will develop guidelines to be implemented project-wide for the management of technical data. The data management function will ensure uniformity of data storage and retrieval through a technical information system. It will provide requirements for project documentation including preparation, submittal, storage, distribution, retrieval, and archiving of such documentation to ensure that an accurate and complete historical record of the project is maintained. In addition, a research support function will be provided to establish guidelines for the exchange of technical information among project participants and between the project and outside organizations.

Sub-areas

2.1.1 Technical Information System

This sub-area will develop a system of hardware, software, and procedures for the management of technical information. Protocols will be developed for storage and retrieval of technical information, and data formats and communication interfaces will be prescribed. The technical information system will ensure that specified data and associated information are managed uniformly throughout the project. A control system will be established to ensure quality and currency of data. This sub-area will provide for the identification of data and information management requirements, preparation of hardware and software specifications, preparation of a technical information management plan, development of software systems to meet requirements, configuration of hardware systems, and installation and operation of hardware and software systems.

2.1.2 Documentation

Work performed in the documentation sub-area will ensure that management systems and procedures are established to collect and preserve information generated during the course of the project. This information will serve as a historical record of work activities and will be preserved and archived in a manner that facilitates effective retrieval. Procedures will be prepared that place requirements on the project areas for documenting technical work and that provide direction regarding formats and criteria for submitting documents as well as for retrieving, distributing, and archiving documents. A computerized tracking system will be established for cataloguing documents during distribution, storage, archival, and retrieval activities.

2.1.3 Research Support

Pursuant to MinChernobyl guidance, this sub-area will create and establish guidelines for a system to provide for the exchange of technical information and documents among the program participants and between the program and outside organizations. Guidelines will include subjects such as technical information release, interfaces for information transfer, and a system for responding to and tracking information requests.

Technical Support Management Area 2.2—Technical Services

Technical support common to two or more project or management areas will in general be furnished from this Management Area. Initially, this will include common field instrumentation, analytical laboratory services, wide-area contamination surveys, radiation protection, dosimetry, personal decontamination, and meteorological and statistical support. Other technical service areas may be added as required.

Sub-areas

2.2.1 Common Field Instrumentation

In consultation with all project areas, a catalog will be developed of instrumentation planned for field use. This catalog will be reviewed for commonalty and interchange ability. Plans will be developed and implemented for procurement, calibration, maintenance, and related services.

2.2.2 Analytical and Radiological Laboratory

The laboratory will provide a full range of services using both fixed and mobile facilities. Services to be provided will include coordination of sampling, sampling protocols, sample preparation, counting, chemistry, radiochemistry, spectral analyses, sample management and archiving, and the provision of calibration standards

and services. The laboratory will also provide calibration maintenance and repair services for specified field instrumentation.

2.2.3 Contamination Survey

Surface concentrations of gamma-emitting radionuclides will be measured over the entire affected area, using airborne detection and positioning systems. Spectral information will be plotted on geographic maps and entered into the master data base. Finer-grained surveys will be made with ground-based and hand-held instruments. Statistical methods will be used to develop surface and subsurface sampling plans, which will be implemented in all areas of known or suspected contamination.

2.2.4 Radiation Safety

Radiation safety services will be provided for all project participants. Included will be the provision of personnel dosimeters, protective clothing and equipment, and decontamination of personnel, clothing, and equipment, as well as collection of samples for bioassay as required. Individual dose records will be established and maintained. Environmental monitoring of work sites will be provided as required.

2.2.5 Meteorology Support

Historical data will be assembled and examined to assist in site characterization and migration/suspension studies. A forecasting capability will be established to assist in project scheduling and in radiological safety planning. Real-time meteorological monitoring networks will be maintained as required in and around contaminated work sites.

2.2.6 Statistical Support

Statistical methods will be applied in many aspects of both field and laboratory work. Statisticians will assist in the design of sampling plans, in selecting samples for analysis, and in interpretation of results.

Technical Support Management Area 2.3—Training Program

In order to maximize the opportunity for Ukrainian nationals to participate through employment in the project, an extensive training program will be conducted throughout the duration of the project. Individual jobs and team tasks will be identified to be performed under supervision of Ukrainian subcontractors, pursuant to direction of program project personnel. Prospective subcontractors will be provided assistance and training in business organization and management to facilitate their early integration into the program team. For each job specialty, the training organization will develop and implement pre-employment screening standards, training plans, and certification procedures.

SUB-AREAS

2.3.1 Program Development

In coordination with project and management area leaders, this sub-area will establish quantitative and qualitative training needs, assist with the development of lesson plans and training aids, and arrange for recruitment and training of Ukrainian instruction staff. It will also arrange for and coordinate translating and interpreting services.

2.3.2 Facilities

Through the use of Ukrainian subcontractors, facilities will be identified or established, equipped for training, and maintained and operated. Required transportation, feeding and other support, including administrative services, will be similarly provided.

2.3.3 Guidance Manuals

This sub-area will provide to all participating contractors guidance manuals for use in developing their individual components of the training program. Formats, introductory material and assistance will be provided for the development of readily translatable text. The guidance manuals will address availability and preferences for training aids, customary instructional techniques, and cultural considerations as well as existing sources of reference materials in the native language.

2.3.4 Program Implementation

The training program will be implemented early in the project, in accordance with the overall training plan. Progress will be continuously monitored and evaluated to assess and improve training effectiveness.

3.0 OPERATIONS PROJECT AREAS

Operations Project Area 3.1—Decommissioning Power Plant

This project area addresses all of the activities required for the decommissioning of the operable reactors at the Chernobyl site. This will require the removal of fissionable components of the units, removal and disposal of contaminated items, decontamination to the extent possible of on-site facilities and equipment, and the placement of all items in a safe configuration.

The sub-projects described below must, in general, be accomplished sequentially, since the start of one may require the successful completion of the other.

SUB-PROJECTS

3.1.1 Prepare Written Decommissioning and Decontamination Plan

A plan and schedule for the decommissioning of the reactors will be prepared for the review and approval by MinChernobyl. The plan will contain the standards to be met by the decommissioning activities and the schedule will contain options for delays in the decontamination should this appear desirable.

3.1.2 Interim Safety Measures

Safety measures to be in place during the decommissioning phase will be identified and implemented. These will include, but not be limited to:

- Establishment of a site-wide monitoring and surveillance system;
- Provision of fire protection systems or supplement existing systems during decommissioning;
- Provision of additional ventilation to accommodate radioactivity which may be released during decommissioning and decontamination;
- Review of structural and foundation capacity of long-term viability; and,
- Shutting off and sealing all passageways and openings not in use to restrict possible release of radioactivity.

3.1.3 Decommission Reactors

In order to proceed with the decommissioning and decontamination of the three operable reactors at the Chernobyl site, it is first required that they be placed in a non-critical configuration, and that it be assured that they cannot be restarted. Initially, this is achieved by the insertion of poison control elements, but modifications to the control system and eventual removal of fuel is also required.

3.1.4 Reactor Cool-Down

Following reactor shutdown, it will be necessary to maintain coolant circulation to remove the decay heat residual. The length of time this is required depends on the fuel loading, fuel burn-up and recent operating history of the reactor. Cool-down progress is monitored by temperatures in the reactor, but may vary within individual fuel elements. For this reason, calculations of heat generation as well as measurements will be employed.

3.1.5 Remove Fuel

Following the reactor cool-down period, removal of the fuel from the reactor vessel can be accomplished. This operation will be completely remote and will be accomplished with the existing fuel handling equipment. The fuel will then be either placed in additional cooling or packaged for disposition. The decision will depend on the fuel conditions at the time of cool-down and the facilities available to receive the spent fuel.

3.1.6 Liquid Decontamination

With fuel removed from the reactor, decontamination of the coolant loops can proceed. This will first require sampling for radioactive and other pollutants, then treatment. Treatments may include filtration, precipitation, ion exchange or evaporation. The goal is to dispose of the water completely, leaving only residues to be disposed of as radioactive waste.

3.1.7 Cleanup and Dismantle Facility and Equipment

With the reactor facility empty of fuel and liquid, disassembly of equipment and facilities can be accomplished. Detailed monitoring of each item will be required to determine the proper safe procedure for decommissioning and the proper disposal method. Material which can be decontaminated for reuse will be treated accordingly. Equipment such as control room components and electrical generators will be examined for possible reuse. Activities related to the cleanup of Unit 4 will be surveyed for possible synergism.

3.1.8 Containment

The reactor vessel, primary shielding, and structure surrounding the reactor may be too radioactive to be safely dismantled. This portion of the facility will be contained and sealed for long-term, on-site monitoring to prevent release of radioactivity to the public.

3.1.9 Waste Management

All components removed from the reactor and all waste generated during decommissioning and decontamination operations will be treated or packaged for disposal. Concurrent activities associated with the Unit 4 contamination remediation project will be utilized whenever possible.

Operations Project Area 3.2—Reactor 4 Site

This project area has two major purposes: 1) to design and implement as rapidly as feasible the measures necessary to prevent any further accidental release of radiation from the Reactor 4 site or other occurrence that may pose an environmental or population hazard, and 2) to develop, design, and implement a comprehensive plan to render the Reactor 4 site radiologically safe and environmentally benign.

SUB-PROJECTS

3.2.1 Existing Conditions Assessment

This sub-project team will collect and examine all available data concerning the current condition of the reactor site; interview knowledgeable officials, scientists, and technicians; and conduct exploratory and diagnostic activities leading to a complete characterization of the facility.

3.2.2 Interim Safety Measures

This sub-project team will design and implement interim safety measures that will improve safety in and around the Reactor 4 site pending implementation of permanent remediation measures. Using the results of the assessment of existing conditions, an evaluation will be made of the risks to site workers, the surrounding population, and the environment resulting from the current conditions. Interim measures will then be identified to reduce or eliminate these risks. Such measures will include improved fire protection, increased structural support, and removal and disposal of unneeded structures and hazardous materials. Specific near-term remediation measures will be recommended, and those approved will be implemented.

3.2.3 Best Case for Fuel Removal

The purpose of this sub-project is to develop and present the best case for removing the melted fuel from the damaged reactor and its surroundings. Methods to accomplish removal will be examined, and a summary safety assessment will be prepared to identify the hazards and risks associated with this course of action. Decontamination or other remediation of the structures remaining after fuel removal also will be addressed.

3.2.4 Best Case for Fuel Containment

The purpose of this sub-project is to develop and present the best case for containing the melted fuel in the damaged reactor site. Alternative and improved methods of containment will be examined to select the one presenting the least long-term risk and lowest long-term maintenance cost. A summary safety assessment will be prepared to identify the hazards and risks associated with this course of action.

3.2.5 Technology Recommendation

Following the development of detailed analyses of the two major remediation alternatives (removal and containment), a preferred course of action will be recommended. In addition to the purely technical evaluation of alternatives, this recommendation will consider the economic and environmental cost and public acceptance of the proposed post-remediation site condition.

3.2.6 Design

Upon acceptance by MinChernobyl of the action recommended, design criteria will be developed and incorporated in a request for proposal, to be issued by MinChernobyl, seeking international competition for the containment design contract. During the design phase, this sub-project will provide progress monitoring and an independent review of the design effort.

3.2.7 Construction

Following completion and acceptance of the design, the same procedures (i.e., criteria, request for proposal, independent review) will be followed for construction of the containment system.

3.2.8 Surveillance

Following completion of the Reactor 4 site construction, long-term monitoring of the facility and site will be required. This sub-project will provide a detailed surveillance plan that identifies measurements to be made, location and frequency of measurement, scheduled analysis and interpretation of results, and independent review and documentation.

Operations Project Area 3.3—Contamination Migration

There are two principal modes of contamination transport or migration: air and water. The transport of contamination by air, immediately after the accident and in the intervening years has spread contamination to the west and to the northeast. The water flow for both groundwater and surface water tends to be in the opposite direction of the air transport. Water tends to move contaminated material to the south.

For this situation to be controlled and eventually eliminated, two things must be accomplished. First, the release of new contamination to the environment must cease, Second, the mechanics and chemistry of the contamination transport modes must be understood and then corrected. This involves the identification, characterization and elimination of existing and potential sources of new contamination release, the computer modeling of the air and water transport phenomena, and the modeling of the chemistry interaction of contamination particles in the environment.

A third mode of contamination migration is through the biological food chain. This mode is addressed in Project Area 3.4—Agriculture and Food.

SUB-PROJECTS

3.3.1 Air

The air contamination transport mechanism will be characterized through the review of existing data, acquisition of new meteorological data, performance of re-suspension studies, and air transport modeling. Remediation technologies will be identified, and appropriate technologies will be selected for implementation. The selected technologies will then be implemented.

3.3.1.1 Re-suspension Studies

In these studies, the team will review and assess the adequacy of existing information (to include meteorological data) related to the evaluation of the airborne transport mechanism for contaminant dispersal. Additional data and information needs will be identified and methods will be defined to acquire the data and information. In addition, a program will be developed and implemented to acquire meteorological data throughout the Chernobyl accident contamination remediation program. Re-suspension mechanisms (to include high winds, fires, and dust created during agricultural activities) will be defined, and analytical and field studies will be conducted to characterize these postulated events in terms of the potential for re-suspension, mass loading, particle size, dispersion characteristics, and radionuclide content, among others.

3.3.1.2 Air Transport Modeling

A model will be established for analyzing the transport of contamination through the atmosphere. Existing models will be identified and assessed for their applicability to the Chernobyl conditions. Based on predetermined criteria for model performance, specific models will be selected and/or developed that will appropriately represent the air transport characteristics of the region. Models will use existing meteorology data and new data as they become available, as well as contamination data and results of the re-suspension studies, to determine and predict the nature and extent of contamination transport.

3.3.1.3 Air Remediation Technology Evaluation

The results of the re-suspension studies and the air transport modeling will be used to characterize the contamination resulting from airborne transport of the region affected by the Chernobyl accident. Remediation technologies will be identified that could have a mitigating effect on the dose resulting from re-suspension and air transport. For the purpose of evaluation, remediation technology performance criteria will be identified using standards developed for cleanup. Viable technologies for remediation will be identified and described. Remediation alternatives will be developed using the identified technologies, and each alternative will be characterized and evaluated in terms of the performance criteria. Alternatives will be ranked based on the results of the evaluation, and remediation measures will be recommended.

Among these measures may be:

- washing,

- fixation,
- restrictions on land use,
- agricultural practices, and
- concentration and removal of contaminants.

3.3.1.4 Air Remediation

Following acceptance and approval of remediation options, the project team will either implement each approved recommendation or assist MinChernobyl in its implementation. This sub-project team will provide a remediation technology implementation plan, identify and acquire resources, implement the selected options, monitor and control performance of the implementation activities, and perform post-remediation verification for effectiveness. Periodic progress reports will be provided, and a post-remediation status report will be prepared.

3.3.2 Water

This project area will determine the contamination levels in water sources (i.e., surface water, groundwater, storm water, and silt and sediment), characterize the transport of contaminants, evaluate remediation technologies, and recommend specific remediation alternatives for addressing unacceptable contamination migration in affected water sources. This project area team will collect site information to establish contamination levels, develop and use water models, identify and characterize remediation technologies, and recommend appropriate remediation technologies for implementation.

3.3.2.1 Existing Information Assessment and Site Characterization

Relevant information related to site characterization for water will be identified using multinational sources. The information will be collected and assessed as to quality and adequacy for characterizing the nature and extent of contamination; predicting the fate and transport of contaminants in surface water, groundwater and sediments; and evaluating risks to the area inhabitants from the drinking water supply. The adequacy of available information for evaluating remediation technology options will also be assessed. A plan for additional data collection to fill data gaps will be developed, and sampling and analyses will be performed to characterize the water quality of the site. This information will provide input to the modeling of contaminant transport through the water pathway.

3.3.2.2 Fate and Transport Modeling of Pripyat and Dnieper River and Other Surface Waters

This sub-project will include development and use of models of the Pripyat and Dnieper Rivers and their associated transport characteristics. The objective will be to evaluate existing conditions, assist in developing a monitoring program, and assess the effectiveness and impacts of remediation measures. The evaluation will use reports of past modeling efforts and previously gathered data as well as field measurements yet to be made. Models will be developed or modified and used as a basis for defining the data requirements and the need for additional measurements. Modeling will then be conducted to evaluate the contamination transport characteristics of the rivers. The models will be used to accomplish the following:

1. assess critical gaps in available information needed to characterize surface flow systems and transport mechanisms;
2. prioritize data needs for site characterization;
3. evaluate baseline concentrations of radionuclides in surface water under conditions of no remedial action; and,
4. evaluate the consequences and effectiveness of alternative remediation actions for contaminated surface water.

3.3.2.3 Fate and Transport Modeling of Groundwater

This sub-project will construct and calibrate models that adequately represent the site-specific fate and transport mechanisms for groundwater and will use these models to accomplish the following:

1. assess critical gaps in available information needed to characterize subsurface flow systems and transport mechanisms;
2. prioritize data needs for site characterization;
3. evaluate baseline concentrations of radionuclides in groundwater under conditions of no remedial action; and,
4. evaluate the consequences and effectiveness of alternative remediation actions for contaminated groundwater.

3.3.2.4 Storm Water Impact Evaluation

This sub-project will evaluate the impacts of storm water on the transport of contamination to various receptors, including surface water bodies, groundwater, and

soils. Previous studies and investigations of storm water in the area will be identified including studies directly related to the accident as well as other storm water and drainage studies such as drainage master plans, non-point source investigations, and storm water management modeling efforts. Based on the review of past work, areas of particular concern will be identified and studies and evaluations will be prepared to define the problem and facilitate design of remediation measures. Parameters that need to be quantified include contamination sources to other media, such as surface water and groundwater. Models to be used will include those previously used for Chernobyl, as well as state-of-the-art models from other sources.

3.3.2.5 Water Remediation Technology Evaluation

This sub-project will provide an evaluation of the different methods for water remediation applicable to this project. Information will be obtained on existing remediation technologies and will be combined with the results of the site characterization, fate and transport modeling, and storm water impact evaluation sub-projects. The remediation technology information and the results will be used to identify suitable technology alternatives to remediate unacceptable contamination conditions for rivers, surface water, groundwater, and storm water. For the purpose of evaluation, remediation technology performance criteria will be identified using standards developed for cleanup. Viable technologies for remediation will be identified and described. Remediation alternatives will be developed using the identified technologies, and each alternative will be characterized and evaluated in terms of the performance criteria. Alternatives will be ranked based on the results of the evaluation, and remediation measures will be recommended. Included among these measures may be re-routing or diversion of sources, settling and precipitation of contaminants, restricted use planning, and treatment at the point of use.

3.3.2.6 Water Remediation

Following acceptance and approval of remediation options, the project team will either implement each approved recommendation or assist MinChernobyl in its implementation. This sub-project team will provide a remediation technology implementation plan, identify and acquire resources, implement the selected options, monitor and control performance of the implementation activities, and perform post-remediation verification for effectiveness. Periodic progress reports will be provided, and a post-remediation status report will be prepared.

3.3.2.7 Silt and Sediment Remediation Technology Evaluation

This sub-project will provide an evaluation of the different methods for silt and sediment remediation. Based on the site characterization and past modeling work, the areas where silt and sediments may need remediation will be identified. A preliminary evaluation of these areas will be made to facilitate review of the available technologies and will include estimates of volumes and generic location (i.e., wetland, river, or reservoir). In postulating possible remediation options, available technologies will be reviewed for applicability, environmental impacts, local capabilities, and costs. Local availability of capabilities and resources will be significant factors in technology evaluation. For the purpose of evaluation, remediation technology performance criteria will be identified using standards developed for cleanup. Viable technologies for remediation will be identified and described. Remediation alternatives will be developed using the identified technologies, and each alternative will be characterized and evaluated in terms of the performance criteria. Alternatives will be ranked based on the results of the evaluation, and remediation measures will be recommended. These measures may include dredging, capping, treatment, and disposal.

3.3.2.8 Silt and Sediment Remediation

The result of the site characterization and the silt and sediment remediation technology evaluation sub-projects will be a set of recommended alternatives for silt and sediment remediation. This sub-project will provide a remediation technology implementation plan, identify and acquire resources, implement the selected options, provide a performance monitoring and control function for the implementation activities, and perform post-remediation verification for effectiveness. Periodic progress reports will be provided, and a post-remediation status report will be prepared.

Operations Project Area 3.4—Agriculture and Food

SUB-PROJECTS

3.4.1 Biota

The biota of the contaminated area affect dosage to man in two ways: (1) by serving as a mechanism or vector for the entry of radioactive contaminants into man's food chain, and (2) by serving as a means of transport from one geographic area or

environmental compartment to another. This project area will catalog the biota of the affected areas, assess their contribution to population dose, evaluate remedial technologies, and recommend remedial actions.

3.4.1.1 Food Chain Characterization

The food chain to man will be described in detail to identify potential pathways to man for radioactive contaminants. Samples of food-chain constituents will be analyzed for concentrations of radioactive elements and the results entered into a data base for dose assessment. Food consumption patterns will be studied and a diet model constructed for each segment of the population (e.g., age groups, rural vs. urban, etc.). With these diet models and contamination levels determined by laboratory analyses, the un-remediated dose commitment will be calculated.

3.4.1.2 Transport Characterization

All of the flora and fauna of the affected region will be catalogued, and their potential for contributing to the transport of radioactive contaminants from one region or area to another will be evaluated. Transport models will be constructed and used to predict contaminant migration (both qualitatively and quantitatively) in all affected areas.

3.4.1.3 Biota Remediation Technology Evaluation

Techniques will be evaluated for reducing dose to man caused by food-chain contamination or entrainment of contaminants and transport out of controlled areas. For the purpose of evaluation, remediation technology performance criteria will be identified using standards developed for cleanup. Viable technologies for remediation will be identified and described. Remediation alternatives will be developed using the identified technologies, and each alternative will be characterized and evaluated in terms of the performance criteria. Alternatives will be ranked based on the results of the evaluation, and remediation measures will be recommended. These measures may include such elements as:

- Cleanup and removal,
- Fixation,
- Elimination or control of vector species,
- Modification of agricultural practices,
- Changes in land utilization, and
- Changes in food processing or dietary custom.

3.4.1.4 Biota Remediation

Following acceptance and approval of remediation options, the project team will either implement each approved recommendation or assist MinChernobyl in its implementation. This sub-project team will provide a remediation technology implementation plan, identify and acquire resources, implement the selected options, monitor and control performance of the implementation activities, and perform post-remediation verification for effectiveness. Periodic progress reports will be provided, and a post-remediation status report will be prepared.

Operations Project Area 3.5—Drinking Water

At the present, radioactive contamination of the potable water supply does not appear to be a problem. However, existing data on water, silts and sediments, as well as current computer based models indicate radioactive contamination is being transported by water. This creates a situation where the public water supply may become threatened with contamination.

SUB-PROJECTS

3.5.1 Drinking Water Supply Characterization

An assessment will be performed to characterize drinking water sources in terms of origin, manner of collection, and manner of distribution and delivery to users. Public and private water supplies will be identified, and existing water quality data and additional water sample data will be reviewed to characterize the extent of contamination. An evaluation will also be performed to locate and identify contamination sources and mechanisms and to delineate affected areas and water sources.

3.5.2 Drinking Water Remediation Technology Evaluation

Using the results of the supply characterization, the team will evaluate different methods for reducing contaminants in drinking water. For the purpose of evaluation, remediation technology performance criteria will be identified using standards developed for cleanup. Viable technologies for remediation will be identified and described. Remediation alternatives will be developed using the identified technologies, and each alternative will be characterized and evaluated in terms of the performance criteria. Alternatives will be ranked based on the results of the evalua-

tion, and remediation measures will be recommended. These measures may include cleanup of ponds and reservoirs, filtration, development of alternative sources, and treatment at point of use.

3.5.3. Drinking Water Remediation

The results of the drinking water remediation technology evaluation will provide a set of recommended alternatives for drinking water remediation. This sub-project team will provide a remediation technology implementation plan, identify and acquire resources, implement the selected options, monitor and control performance of the implementation activities, and perform post-remediation verification for effectiveness. Periodic progress reports will be provided, and a post-remediation status report will be prepared.

Operations Project Area 3.6—Soils

The soils of the contaminated area contribute dosage to man in four ways: (1) external radiation dose to those occupying or working the land; (2) leaching into groundwater with subsequent transport into domestic water supplies; (3) re-suspension in air, creating a respiratory hazard; and (4) uptake by plant and animal species, resulting in direct or indirect entry into man's food chain. This project area will characterize the soils in the affected area, determine the distribution and nature of the contamination, and determine the significance of all the above-described pathways. Remediation technologies will be evaluated, remedial recommendations will be developed, and approved recommendations will be implemented.

SUB-PROJECTS

3.6.1 Site Characterization

Based upon the results of the aerial contamination survey (see Support Management Area) and other available soils data, a sampling plan (including extensive depth profiling) will be carried out, covering all known or suspect areas. Samples will be examined and analyzed for radionuclide concentrations and chemical and physical form.

3.6.2 Hazard Determination

Using statistical and modeling techniques, the hazard to man will be estimated for each pathway, each geographical area, and each potential land use.

3.6.3 Soils Remediation Technology Evaluation

This sub-project will use the results of the site characterization and hazard determination sub-projects to evaluate methods for reducing contaminants in soils. For the purpose of evaluation, remediation technology performance criteria will be identified using standards developed for cleanup. Viable technologies for remediation will be identified and described. Remediation alternatives will be developed using the identified technologies, and each alternative will be characterized and evaluated in terms of the performance criteria. Alternatives will be ranked based on the results of the evaluation, and remediation measures will be recommended. Among these may be:

- soil removal,
- soil treatment (additives),
- changes in land usage,
- modification of agricultural practices, and
- crop selection.

3.6.4 Soils Remediation

Following acceptance and approval of remediation options, the project team will either implement each approved recommendation or assist MinChernobyl in its implementation. This sub-project will provide a remediation technology implementation plan, identify and acquire resources, implement the selected options, monitor and control performance of the implementation activities, and perform post-remediation verification for effectiveness. Periodic progress reports will be provided, and a post-remediation status report will be prepared.

Operations Project Area 3.7—Waste Management

This project area addresses all of the activities required for the location, identification, retrieval, handling, decontamination, treatment, transportation, packaging, disposal, surveillance, and documentation of radioactive waste. This project area covers all aspects of waste management from initial planning to ultimate disposal .

SUB-PROJECTS

3.7.1 Waste Characterization

In order to plan for and accomplish the proper management of the radioactive waste resulting from the Chernobyl accident, sampling and analyses will be conducted to characterize and classify the wastes as to form, physical and chemical properties, quantity, geographic distribution, and assay of specific nuclides.

3.7.2 Waste Management Technology Evaluation

This sub-project will identify and evaluate existing technologies for radioactive waste management. Emphasis will be placed upon existing and proven technologies. However, new technologies will undoubtedly emerge during the course of the project, and a concerted effort will be made to identify and adopt significant technology improvements as they become available.

3.7.3 Retrieval of Temporarily Stored and Buried Waste

Over the past five years, radioactive materials have often been collected in temporary storage areas. All of these locations will be identified and the contents will be determined and documented. Waste to be retrieved will be classified, and retrieval plans will be developed and implemented. Retrieval will generally be accorded lower priority than other waste management efforts except in cases where the current status of temporary storage sites represents an immediate hazard to public health and safety.

3.7.4 Decontamination

In the evacuated cities of Pripyat and Chernobyl, as well as elsewhere in the near vicinity of the reactor site, a large number of otherwise intact and usable structures will require evaluation and either decontamination and repair or demolition. In either case, considerable contaminated waste will be generated and will require disposal. Decontamination technologies will be identified and selected for application based on the type, form, and extent of contamination. Although decisions in this sub-project will, in general, be guided by cost-benefit considerations, close coordination with Ukrainian authorities will be required in order to ensure the preservation of items of historic and cultural significance. This sub-project will also provide for the decontamination or disposal of vessels, vehicles, and large items of construction equipment.

3.7.5 Site-Generated Waste

Waste treatment, decontamination, and other project activities may generate additional waste by distributing the existing radioactivity into materials that were originally clean (e.g., decontamination solutions). The volume, properties, and radioactivity of this waste will be determined in order to provide for its proper handling and disposal. Each sub-project will result in estimates of site-generated wastes, and technologies for their packaging and disposal will be identified and selected.

3.7.6 Repositories

This sub-project will define the requirements for radioactive waste repositories, perform repository site characterizations, recommend locations where such repositories can be built, provide design criteria for the repositories, plan for design and construction, and recommend waste acceptance criteria and procedures for monitoring, surveillance, and documentation.

3.7.7 Transportation, Packaging, and Handling

Waste management activities during the cleanup will require the handling of radioactive waste, packaging of some wastes, and transportation of the waste to the disposal site or repository. Some waste will be of sufficiently low levels of radioactivity to permit contact handling while some will require remote operations. This sub-project will involve analysis of handling requirements for the different types of waste as well as the requirements for packaging and transportation. Equipment to perform these operations will then be specified and procured. Operating standards and procedures will be developed for these activities.

3.7.8 Waste Treatment and Disposal

In order to render them suitable for permanent disposal, some wastes will be concentrated, solidified, or otherwise treated. Depending on the waste form (liquid, solid, etc.) and its radioactivity, different treatment and disposal options will be selected. This sub-project will address the processes, equipment, and operations required to perform the options. Treatment requirements will be identified as disposal standards and waste characterizations are developed. Waste treatment equipment will be procured and operations defined.

3.7.9 Waste Documentation

A necessary activity during decontamination, cleanup, and disposal is documentation of the results. Detailed records will be maintained describing the final disposi-

tion of waste, including its quantity, concentrations of contaminants, form, packaging and containment features, and location.

Operations Project Area 3.8—Health Care

SUB-PROJECTS

3.8.1 Epidemiological Studies

Epidemiological studies of the general population within the affected area

1. Baseline evaluation of health status, including exposure to toxic substances not related to Chernobyl, general nutrition and immunization status.
2. Periodic (6 month to 1 year) evaluation of health status via physical examination and baseline laboratory studies.
3. Ongoing compilation of data that results from the initial and periodic health status evaluation.
4. In order to make this data base as complete as possible, information from episodic or emergency visits, when not received in the same center as the health status evaluation, must be made available to data collectors.

3.8.2 Health Care Facilities

Health care centers for the use of workers, as well as the general population in the affected area, should be established to provide consistent health care and facilitate record keeping and epidemiological evaluation of data.

1. These facilities should be equipped with basic laboratory and radiological equipment to enable diagnosis of episodic and emergent, as well as long-term alterations in health.
2. Medications, intravenous fluids, sterile equipment, including syringes and disposable needles, as well as dressing supplies, will need to be available. Sterilization equipment for reusable instruments will need to be at each site, as well.
3. Inventory of equipment, supplies, and pharmaceuticals will need to be done on a regular basis to ensure the security and efficiency of each center.
4. Disposal of contaminated equipment and supplies will be handled according to approved procedures for the type of contamination, e.g. needle disposal.

Operations Project Area 3.9—Population Care

This area includes all activities necessary to provide human habitation and communities. Thus, it includes construction materials production, construction of homes and communities, and provision of community facilities and services. Detailed breakdown of sub-projects will be prepared in Phase Two.

4.0 TECHNOLOGY ASSESSMENT, ENHANCEMENT, AND TRANSFER

Task 4.0 will span all four Phases of the project.

TECHNOLOGY ASSESSMENT, ENHANCEMENT, AND TRANSFER PROJECT AREA 4.1 DATABASE DEVELOPMENT

The purpose of this project area is to develop the needed databases for characterization of both the waste and the site, including surface contamination characterization, ground water contamination characterization, and atmospheric characterization. This project area will then integrate these databases with existing technologies and operational experiences.

SUB-PROJECTS

4.1.1 Waste Characterization

This task will involve determining and monitoring the characteristics of radioactive waste in situ. Waste characterization will be done remotely with robotic monitoring techniques which employ sensor- and model-based control software to measure temperature, humidity, pressure, presence of oxygen or hydrogen, broad-band gamma sensors, gamma spectrometers, gas chromatography, and physical sensors for mapping the inside of the sarcophagus. For analyses that cannot be carried out in situ, automated chemical analysis laboratories will be utilized.

4.1.2 Site Characterization

4.1.2.1 Surface Contamination Characterization

Aerial gamma and neutron survey data will be integrated with spot surface sample analyses. The entire database will then be interpreted in terms of decay, mobility, and consequence models. Gamma-ray passive tomography will be utilized to locate fission products under concrete and soil surfaces for a considerable distance around the Chernobyl reactor site. Three-dimensional source distribution maps will be developed.

4.1.2.2 Ground Water Contamination Characterization

The two critical pathways for ground water contamination at the Chernobyl site that lead to human exposure, i.e., ground water and surface water, will be identified. In order to characterize the contamination, the physical and chemical processes expected to occur at or near the site will be considered.

4.1.2.3 Atmospheric Contamination Characterization

Characterization of the atmospheric contamination will be accomplished via aerial gamma and neutron survey data. In addition, meteorological data will be acquired to improve models for the air transport of contamination. Parameters to be investigated include the particle size distribution, dispersion characteristics, and the radio nuclide content.

4.1.3 Existing Technologies

A survey of existing technologies which may be beneficial to the Chernobyl Comprehensive Environmental Remediation Project will be performed. These technologies include: radiation survey capabilities (surface, ground water, and aerial); health physics monitoring and radiation protection; source term analysis methods; containment concepts; geologic performance assessment methods; and, the use of robotics for cleanup of radioactive sites.

4.1.4 Operational Experience

The experience gained in applying the technologies mentioned above in ongoing projects will be of great benefit to the Chernobyl cleanup efforts. This includes: the reactor decontamination and decommissioning technologies used at Three Mile Island; the development of high-level radioactive waste storage and transport containers; and, the development of the Waste Isolation Pilot Plant, a Monitored Retrievable Storage facility; and, the final repository.

TECHNOLOGY ASSESSMENT, ENHANCEMENT, AND TRANSFER PROJECT AREA 4.2 PRELIMINARY HAZARD ASSESSMENT

This section describes the identification, evaluation, and selection of models required to assess the effects of radio nuclides that have been or that may be released as a result of the 1986 incident at Chernobyl Unit #4. These models could also be used to evaluate many of the hazards from the continued operation of Units #1 and #3. Unit #2 has been shut down since a fire occurred within the generators in 1991. It is anticipated that all four reactors at Chernobyl will be decommissioned and decontaminated in the near future. The fate of the partially constructed Units #5 and #6 is undetermined.

A preliminary hazard assessment for the Chernobyl site would include five general steps:

Step 1—Identification of pathways of potential exposure.

Step 2—Screening of those pathways to identify which are of primary importance.

Step 3—Identify models that can be used to assess the pathways and to demonstrate that those models can be integrated into a total system performance assessment.

Step 4—Select computer codes that reflect the models and implement the methodology.

Step 5—Acquire, implement, and assess computer codes for the methodology; revise conceptual models, as necessary.

The primary areas considered by this methodology are:

- the location and nature of radio nuclide contaminants
- ground water, surface water, and aerosol transport of contaminants;
- the food chain; and,
- radiological dosimetry.

Other effects, such as inadvertent human intrusion, can be analyzed within this methodology, but are not considered to be of primary importance.

4.2.1 Release Scenarios

Initial identification of natural and man-induced events and processes must be done carefully to increase the likelihood that the list is exhaustive and potentially significant events, and that potentially significant events and processes have not been inadvertently neglected. Events and processes need to be screened on a site-specific basis; the number is usually large. Criteria for this screening are typically:

- physical reasonableness;
- likelihood of occurrence; and,
- potential consequence.

Even after screening of processes and events, the number of scenarios that can be generated is likely to be impractically large. One way to reduce the number of per-

turbations is to include as many events and processes as possible in a base-case scenario.

Scenarios are screened on the same criteria as processes and events:

- physical reasonableness;
- likelihood of occurrence; and,
- potential consequence.

Researchers commonly decrease the number of scenarios by combining those that have similar potential consequences. However, when cumulative likelihood of occurrence, the cumulative likelihood of occurrence can become significant.

Scenario screening should eliminate any scenarios such that only a select number—those with a significant likelihood of occurrence and potentially significant consequences, based on preliminary analyses—remain for further consideration.

4.2.2 Site/Facility Conceptual Model

There are three major areas that require conceptual models for hazard assessment at Chernobyl: 1) waste; 2) engineered facility; and, 3) site. The characteristics of the waste include, among other things, an inventory of waste constituents, including distribution, the quantities of each waste form, decay chains, and the half-lives of the various radio nuclides. The engineered facilities include both the original structures and any post-accident engineered barriers. The current configurations and properties of these facilities must be known. Finally, site characteristics from those in the "near-field" within the Sarcophagus to the "far-field" outside the Sarcophagus must be understood for conceptual model development. Most of the near-field characteristics would be included in the waste and engineered facilities investigations. Far-field areas of importance range from geology (geochemistry, geomorphology, etc.), pedology, hydrology (both surface and subsurface), meteorology, ecology (including agriculture practices), demography (including population distribution and numbers, diet, water source and consumption, and locations of individuals in high-risk occupations or habitations, e.g., farmers), to health physics and radiation medicine (including the effects of external and internal doses and how these affect the body).

4.2.3 Consequence, Uncertainty, and Sensitivity Analyses

Consequence Analysis

Detailed consequence studies of each of the remaining scenarios and the pathways involved in these scenarios must be done. Possible pathways for radio nuclide transport at Chernobyl include atmospheric, surface water, and ground water, food materials, and direct exposure. These pathways must end with their impact on human health.

The output from the calculated source term (i.e., a discharge rate of radio nuclides into the environment as a function of time) serves as an input condition for the various transport codes. Velocity vectors are calculated independently of source term for al transport mechanisms. The output of the geosphere transport model serves as input to the biosphere transport model.

Uncertainty Analysis

Because of the large, temporal, and spatial scales over which risk must be assessed at Chernobyl, the impact of uncertainties on the results of an analysis to predict a system's behavior must be examined. Major areas of uncertainty are: 1) uncertainty in the future state of the system; 2) model uncertainty; and, 3) data and parameter uncertainty. The method most commonly used for propagation of parameter uncertainty to the results of the consequence analysis in Monte Carlo simulation. Uncertainty in the input parameters is described with a probability distribution function. Latic hyper cube sampling is used to generate multiple vectors of input parameter values, and a consequence analysis calculation is performed for each of the vectors. This procedure results in multiple values of the performance measure of interest. These values are then used to express the uncertainty in results. Other methods of considering the uncertainty in parameters are available.

Sensitivity Analysis

Sensitivity analyses examine the relative importance of the various uncertain input parameters to the results of a risk assessment. Risk evaluators commonly use the results of the Monte Carlo simulation described above as the basis for a regression analysis. The regression analysis estimates the values of the coefficients in a regression expression. The relative importance of the uncertain parameters can then be established by examining the magnitude of these coefficients. Other approaches and/or techniques for sensitivity analysis have been published.

One advantage of performing a sensitivity analysis as part of an iterative risk assessment is the feedback process to the site characterization program. This feedback

should provide direction on gathering those data that would make the most important contribution to reduction of uncertainty in the prediction of the risk for the system/site.

It is important to understand that most sensitivity analysis methods only examine the relative importance of uncertain parameters. Uncertainty in the input parameters is commonly far less important than uncertainty in assumptions regarding the conceptual model(s) for the system. A major drawback in the available approaches for sensitivity analysis is their inability to address the importance of uncertainty in assumptions in conceptual models. A critical need is the ability to develop sensitivity analysis techniques that will permit the elucidation of the relative importance of assumptions in conceptual models.

Technology assessment, enhancement, and transfer project area 4.3—Remediation Objectives

This sub-area will address the establishment and evaluation of environmental restoration goals by the project management. This is a critical and complex component of the strategic planning process, as the important factors which shape and define the goals and objectives of the remediation project impose significant constraints on project elements and activities. Issues such as regulatory uncertainty, definition of acceptable contamination levels, and permissible adverse consequences, and measurements of success will pose many challenges to the remediation project. Understanding the impacts of these factors on the project will enhance the evolution of efficient, comprehensive, and defensible planning.

Sub-projects

4.3.1 Regulatory Constraints

Regulations which govern activities for all facets of the remediation project must be carefully understood to ensure that activities are undertaken in a manner which:

1) Ensures regulatory compliance of each specific activity itself, and

2) Ensures regulatory compliance on the outcome of each activity.

The first aspect of regulatory constraints involves the identification of regulatory requirements which directly impact the undertaking of specific activities, such as worker safety, immediate environmental hazards, and waste minimization. The latter aspect encompasses a broader spectrum of regulatory issues which define the fundamental direction and depth of the remediation project, such as how safe is safe, how clean is clean, permanent disposal philosophies, and acceptable risks.

The regulatory environment establishes the framework within which the remediation activities must be planned, undertaken, and executed. The existing regulatory environment must be fully and clearly understood so that current requirement, constraints, shortfalls, and conflicts in both requirements and jurisdictions are known. The choice of specific technological options (such as use of robots versus humans), as well as major program directions (such as minimizing the generation of new wastes versus quicker solutions which generate large volumes of wastes) are impacted by the regulatory environment. A clear understanding of the existing regulatory environment will maximize the likelihood that the proposed project activities address and comply with regulatory requirements, and facilitate identification of potential conflicts between the regulations and proposed goals, methods, and technologies.

The future regulatory environment will be extremely important to the ultimate resolution of the remediation project, as well. Although the future cannot be perfectly predicted, the development of a clear understanding of the current environment, as defined in terms of requirements, constraints, shortfalls, and conflicts, will enhance the capabilities of project management to assess and evaluate the potential impact of proposed regulatory changes. This will enable management to better respond to or challenge such changes.

4.3.2 Evaluation Criteria

The development of criteria for evaluation project goals and the degree or quality to which they are received is crucial to successful project management and defensibility of results. Well-defined, non contradictory criteria provide a solid basis for comparison of options which strengthen arguments for pursuing specific technology options and program directions. Evaluation criteria can be categorized into two major groups—objective and subjective.

Objective criteria involve metrics, guidelines, and standards by which one can quantitatively measure specific quantities relevant to project activities or goals. Examples of such criteria are cost, time, health consequences, risk, and resource requirements. An example of using such criteria for decision purposes might be to measure the trade-offs between monetary costs, resource needs (e.g., manpower) and

health consequences between the choice of using robots or humans for certain remediation activities.

Subjective criteria involve issues or concepts which cannot be consistently quantified according to methods governed by the laws of physics, but which must be considered in the process of deciding technological and programmatic options. Examples of such criteria are aesthetics (the relative weighting of functionality against form), political pressures, religious, and moral standards. Such criteria must be incorporated into the planning and decision process to establish a system of rules and guidelines for assigning quantitative or monetary values to abstract ideas. One example is to place a value on the aesthetic desirability or value of land use options (e.g., restricted use versus public access, or to stabilize existing structures versus returning sites to greenfield), or to place a value on human life or a cost on human suffering.

Two types of criteria must be identified, developed, and incorporated to permit project management the capability to make the most informed and defensible decisions possible.

4.3.3 Success Indicators

The ultimate objective of the Chernobyl Comprehensive Environmental Remediation Project is to return contaminated land areas, water sheds, and industrial facilities to a state that will either remove all hazards and permit human use without danger or prevent human use and exposure to hazards. This outcome will be achieved only after a number of technically complex project activities which behave as a dynamic system of interrelated components have been carefully managed. A vital aspect of this management is the correct identification of inputs and outputs which flow from one activity of this system to other activities.

The development and application of appropriate methods to determine success metrics is crucial for the smooth management of the dynamic system which is embodied by the project activities. The utility of success indicators must be developed with a close linking to the regulatory environment. Both aspects of the project will affect each other. Regulatory requirements will define the success states which must be achieved and measured; scientific knowledge and methods will define project ability to meaningfully measure the achievement of these goals.

TECHNOLOGY ASSESSMENT, ENHANCEMENT, AND TRANSFER PROJECT AREA 4.4—SYSTEMS ANALYSIS

This project area uses the information and analysis performed in the previous areas, i.e., 4.1 through 4.3, as well as additional analyses, to determine the optimal remediation options for the facility and the surrounding site. Technologies that are appropriate for the various options are identified

SUB-PROJECTS

4.4.1 Assessment Model Development

The consequences of mothballing versus decommissioning Chernobyl Reactor #4 are evaluated in this sub-project. This will be done through the use of assessment models which have been created based on the base-case model developed in Project Area 4.2. Similar analyses can be performed for Reactors #1, #2, #3, #5, and #6.

4.4.2 Remediation Option Identification

Given results of the assessment model, potential remedial actions are determined. These remedial actions are chosen based on:

- location and nature of radio nuclide contaminants;
- ground-water, surface-water, and aerosol transport of contaminants;
- the food chain;
- radiological dosimetry; and,
- human interactions.

A risk assessment of the remedial actions, using fault tree and event tree logic, will then be performed. The uncertainty associated with the actions will be included in the model. The model will consider waste transportation, management, handling, storage, confinement, and packaging. Areas that require detailed remediation planning will be identified.

Once conceptual models have been formulated for the diverse areas listed above, computer codes must be selected, modified, or created, as necessary, to accurately reflect the conceptual models. Many computer codes already exist to model both near-field and far-field events and processes. These should be readily applicable to the conditions at Chernobyl. As more data become available, conceptual models and computer codes may need to be revised and refined to reflect new data. In addition, these models and codes can be used to determine the consequences of various scenarios, areas that introduce large uncertainty into the hazard assessment, and the

relative sensitivity of the results of the assessment to the various input parameters. Results from these analyses can be used to direct further data acquisition and/or model refinement. A further discussion of these various types of analyses is presented below.

4.4.3 Options Evaluation

The various options identified in Sub-project 4.4.2 for remediation are evaluated with respect to regulatory constraints, evaluation criteria, and success indicators. The optimal remediation options are determined.

4.4.4 Technology Assessment

This sub-project involves assessing technologies currently available or under development that may be appropriate for the identified options.

TECHNOLOGY ASSESSMENT, ENHANCEMENT, AND TRANSFER PROJECT AREA 4.5—DEVELOPMENT AND DEMONSTRATION

The purpose of this project area is to develop prototype systems required for waste material retrieval, processing, minimization, monitoring, handling, packaging, transportation, storage, and disposal. The systems selected for prototype development will be limited, based on the system analysis discussed in Project Area 4.4, above.

SUB-PROJECTS

4.5.1 Simulation and Proof of Principal

Simulation and proof of principal will be used to demonstrate viability of all candidate technologies and systems. Simulation will be carried out using state-of-the-art computer graphics. This effort can be used to evaluate the time, exposure, required space envelopes, and efficiency of candidate systems. Proof of principal demonstrations will be used with mock-up and prototype systems. This effort will further demonstrate the adequacy of candidate systems, and can also be used for personal training in a cold environment. Improvements and modifications from both of these efforts can be identified prior to production manufacture of the systems.

4.5.2 Prototype System Development

This sub-project will involve the identification of candidate systems which show potential for further development. This further development effort will include the design and construction of prototypes which will be thoroughly evaluated to assess the reliability, performance, radiation hardness, and effectiveness to accomplish the specified tasks. The prototype systems will be full and/or scale size, and will be tested in laboratory surroundings and designed to mock-up as closely as possible to the actual conditions present at the Chernobyl site.

4.5.2.1 Waste Material Retrieval and Handling Systems

Waste material retrieval and handling systems will include remote controlled robotic devices, designed for long-term operation in high-radiation environments. Radiation hardening technology will be developed for robotic systems, and demonstration testing will be performed within hot cells. The retrieval systems will also be capable of moving within areas containing significant numbers and sizes of obstacles.

4.5.2.2 Waste Material Processing and Minimization

Waste material processing and minimization systems development will address the use of technologies such as vitrification, absorption, consolidation, and compaction. The prototype systems for these tasks will be adapted from either existing or developing technologies.

4.5.2.3 Waste Packaging and Transportation

Waste packaging and transportation systems are required to remove the hazardous material from the Chernobyl site to permanent storage or disposal sites. Prototype systems will be developed to demonstrate compatibility with handling systems. Prototypes will also be used to demonstrate compliance of the designs with applicable transport and storage safety regulations.

4.5.2.4 Waste Storage and Disposal

Waste storage and disposal system development will include concept designs or the long-term storage of the hazardous material removed from the Chernobyl site. Long-term safe disposition of the materials requires significant characterization of the selected site for the repository. This characterization will address the geologic, structural, thermal, meteorological, and hydrologic aspects of the site.

Technology Assessment, Enhancement, and Transfer Project Area 4.6—Technology Transfer

Transfer of applicable US DOE technologies for use in Chernobyl decontamination and decommissioning efforts will be based on options identified in Project Area 4.4. Transfer of technologies will proceed in three stages: 1) industrial-scale production or demonstration; 2) personnel training; and, 3) relocation of hardware and personnel to the field. The training stage will overlap the production/demonstration and reallocation stages.

4.6.1 Industrial-Scale Production/Demonstration

Technologies available through the US DOE will be brought to industrial or near-industrial scale prior to application at the Chernobyl site. Full-scale equipment and control technologies, such as telerobotic characterization and demolition equipment, will be integrated by the developing laboratory at a designated demonstration site. Possible process bottlenecks and equipment interface difficulties will then be identified and explored, and necessary refinements made to systems and processes in a non-radiological environment. The following issues will be addressed at this stage:

- Physically evaluate the applied technology
- Demonstrate and improve systems performance and reliability
- Develop and refine procedures
- Clarify personnel needs and training requirements
- Identify further technology or equipment needs
- Minimize radiation exposure through optimal technology application

For technologies that can be used away from Chernobyl, such as mechanical, geological, and meteorological system modeling techniques, validation and verification steps will assure applicability to the Chernobyl activities. Industrial partners will be an integral part of the process to assure that all perceived needs are addressed.

4.6.2 Training

Training of personnel will be critical to the efficient and timely application of decontamination and decommissioning technologies. Facilities will be established for the training of field operators, and could include facilities where the activities described in Section 4.6.1 are establish. Training will begin with introduction to the concepts of the given technology and the application for which it is intended. It will then shift to hands-on experience as the industrial-scale system or technology is determined to be ready. As the operators become familiar with its application, further refinement of the technology by an operator/laboratory team may be made.

4.6.3 Relocation to the Field

When technology and operators are determined to be ready, the technology will be transferred to Chernobyl for applications. The trained operators, supported by the developing laboratory, will be responsible for bringing all equipment and processes on-line.

The three-step technology transfer sequence assures transfer of a field-ready technology and fully qualified personnel to the appropriate application on the Chernobyl decontamination and decommissioning effort.

PHASE THREE

Mobilization, Field Investigation and Feasibility Studies—Mission Statement

Phase Three consists of mobilization, field investigations, and feasibility studies. The purpose is to identify, characterize and define specific environmental, contamination, health and population problems; identify and evaluate specific alternatives for technical approaches and solutions for those problems; and select alternatives to be implemented.

PHASE FOUR

Remediation and Construction—Mission Statement

Phase Four consists of remediation and construction. The purpose of this Phase is the physical implementation of the alternatives selected in Phase Three.

Many Phase Four projects will proceed while Phases One, Two or Three are underway for other projects. A typical example might be the comparison of the Sarcophagus with ground water remediation. The Sarcophagus is a problem that requires immediate attention and expedited remedial actions. Ground water remediation, is a long-term problem that will required collection of a great deal of data before effective measures can be evaluated and alternatives selected for implementation.

PREPARED STATEMENT OF THOMAS F. GARRITY

Good morning! I'd like to open by extending my thanks to this subcommittee for its work in assembling this panel of experts to discuss potential solutions to the long-term effects of the Chernobyl accident. This hearing should provide a much clearer view not only of the potential health effects posed by the accident . . . but also some concrete proposals on how the public and private sector in the U.S. can help meet the public health and technical needs of the Ukraine and the other independent states of the former Soviet Union.

I'd like to also express, on behalf of the General Electric Company, our gratitude for this opportunity to offer our expertise and insights.

As you're well aware . . . Chernobyl was the world's single greatest nuclear accident. The exact toll in human and environmental damage may not be known for many years.

Based upon what we can read and analyze, it is apparent that reactors of the Chernobyl type were designed and constructed far below even the earliest Western technology standards.

Many of these reactors lack the appropriate cooling systems as well as the concrete containment structures necessary to capture radiation in the event of an accident.

This is a crucial issue because as many as 16 reactors of the same design are still operating in the Commonwealth of Independent States. Further, there is no practical method of uprating these plants given the overall lack of sophistication in the equipment . . . and GE has no interest in offering our services to decommission any of these existing plants. Without the necessary technical knowledge of these specific plants . . . such an endeavor would be impossible.

What we do recommend . . . is an in-depth look at alternative forms of energy that could eventually replace these nuclear plants in the CIS.

This is not the first time we have offered our assistance to deal with possible solutions to alternative sources of energy production following the Chernobyl accident. We entered into very active discussions on this topic in both 1989 and 1990. We discovered, however, that there was no commercial basis available to fund any support we may have been able to provide.

We do see two encouraging signs in the CIS that make such a venture more plausible. The first is the apparent trend toward more stability in the regions' governmental structures that may make it easier to pursue future arrangements for assistance. The second is the renewed focus on the Chernobyl crisis on the part of the Western industrialized nations.

It's encouraging, for example, that when the leaders of the G7 met in Munich recently, they recognized that Chernobyl is literally a "ticking timebomb" . . . and while they did not grant the $700 million dollar emergency fund requested . . . they did approve a fund of $100 million dollars to carry out the appropriate emergency measures. We hope that this type of attention to the problem continues toward what is clearly an environment and health disaster waiting to happen.

It is our position that proven Western technology . . . possessed by GE and others . . . already exists that can provide large blocks of electric power in a clean, efficient, cost-effective and environmentally compatible manner . . . and prevent almost any type of disaster.

Today I'd like to give you a brief look at those technologies . . . and discuss why they are best-suited to meeting the current needs of the CIS.

Before doing that however, I'd like to take a moment to convey what we perceive is our role . . . and perhaps more importantly . . . your role in helping provide safe and economical power to the CIS.

Two obstacles exist in dealing with the Commonwealth of Independent States' critical need for power. The first is political the second is technological.

The political instability in the CIS . . . coupled with the inability to meet commercial terms . . . makes it virtually impossible for GE . . . or any company for that matter . . to successfully enter into any agreements . on their own . . . for supplying power to countries in the CIS.

What's needed is your assistance in contacting the appropriate parties . . . making the appropriate diplomatic arrangements . . . and providing the necessary safeguards such as Overseas Private Investment Corporation insurance . . . in sum, facilitating the needed political mandates that will allow GE . . . or any other power supplier . . . to do business in the CIS.

The technological side of the problem is our responsibility . . . and we're more than up to the task. We have technology available that will capably and completely

support any energy option deemed necessary . . . and we're prepared to offer recommendations on what options best match the needs of the CIS.

We would be more than willing to combine our technological expertise with governmental support to form a type of "super jointventure" that would greatly benefit the CIS . . . as well as U.S. industry and trade.

The need is urgent. An ideal window of opportunity for providing power to the CIS is now open that may not come again for quite some time.

Overall power consumption is down some 30 percent due to the shutdown of many military facilities in the region and reduced industrial output. This is a prime opportunity to move the CIS away from the sub-standard technology they now rely upon for their energy . . . to cleaner, safer and more cost-effective forms of power. I urge you to not let this opportunity slip away.

In addition . . . the large supply of natural gas in the region offers a tremendous opportunity for moving to alternative forms of power. Presently, 20 to 25 percent of the CIS's power generation is from natural gas. This gas is being used to fuel relatively old and inefficient steam turbine plants that operate at thermal efficiencies of only 35 percent. At this time . . . a significant portion of the natural gas is escaping into the atmosphere . . . contributing to the overall global pollution problem. Estimates on the amount of natural gas escaping range anywhere from 10 to 25 percent.

Technology can harness this gas . . . and use it to provide economical power for combined cycle powerplants . . . and that's only one example.

Looking at the technologies available . . . they range from long-term remedies such as nuclear power . . . to short-term, faster fixes such as fossil fuel plants and advanced combined-cycle applications.

In my experience . . . I have found it wise for a country to possess a diverse supply of energy options instead of "putting all the eggs in one basket," as it were . . . and primarily relying on a single form of technology. GE offers leading edge technology for both the long-term and the short-term.

In the area of nuclear energy . . . new advanced technologies are being developed that will provide safer, cleaner, and more economical nuclear power.

At GE, for instance, we are working on two advanced Light-Water Reactor designs, sharing a common technology base. The Advanced Boiling Water Reactor . . . or ABWR . . . is a standardized 1300 Megawatt unit, while the Simplified Boiling Water Reactor . . . or SBWR . . . is a smaller, 600 Megawatt configuration.

Both technologies incorporate the best, proven features from boiling-water reactor designs and employ newly developed controls and instrumentation, fuel, and turbine technology, and passive accident mitigation techniques for maximum safety.

We are pleased to report that the ABWR has been adopted as the next generation, standard boiling-water reactor in Japan. In 1987, the Tokyo Electric Power Company announced a decision to proceed with two ABWR units for their Kashiwazaki-Kariwa Nuclear Power Station.

In the United States . . . the ABWR is the lead design scheduled to receive U.S. Nuclear Regulatory Commission approval as the first certified U.S. Standard plant. We expect final approval later this year, with certification to follow in 1993.

Smaller advanced reactor designs with passive safety features are also being developed with support from various governments and industry associations . . . involving unprecedented international cooperation.

As an example, the Simplified Boiling Water Reactor is being developed by a team involving over 25 organizations, from nine countries. While we've just completed the conceptual design phase, the SBWR shows significant technical and economic promise.

GE expects that the advanced safety and performance features of these new generations of nuclear plants, and their successful commercialization in countries such as Japan, will lead to more widespread acceptance of this power source early in the next century.

We are also fortunate to be the world leader in steam turbine-generator technology. GE boasts the latest steam turbine technology using ultra-super critical steam conditions with operating conditions up to 1200 degrees Fahrenheit . . . as well as the largest installed base in the world. Our global installed base exceeds 8,000 units, providing 435 Gigawatts of power.

While nuclear power and steam offer solid advantages . . . the best solution for the CIS in the short term is the advanced combined cycle application.

This technology uses a gas turbine in tandem with a steam turbine. Heat exhaust from a Oil turbine is captured and used to make steam to drive a steam turbine-

generator. The result is a highly efficient use of fuel, with significantly lower emissions than from conventional coal burning facilities.

This is not a new concept. What is new, however, is the highly reliable and advanced technology that enables higher output at even higher efficiency . . . today approaching 55 percent compared to the average 35 percent efficient gas-fired plants now operating in the CIS. It would represent a new direction in power generation for the CIS . . . which now lacks any viable gas turbine technology.

Advanced combined cycle technology owes most of its advantages to the maturation of gas turbine technology.

Today's advanced heavy-duty gas turbines are the result of four decades of technology evolution. Over this time the combustion turbine has gone from a relatively low output, high maintenance peak demand, power source . . . to a highly reliable, high-efficiency, low maintenance base load technology.

To put these advancements in perspective, GE's first gas turbine, delivered in 1949, was a 3.5 Megawatt unit with a firing temperature of 1400 degrees F and an efficiency rating of 16 percent.

In contrast, today we're delivering 226 Megawatt gas machines with firing temperatures over 2350 degrees F with combined cycle efficiencies of 55 percent. Quite a difference.

Current combined cycle plants are an extremely efficient energy option . . . operating at thermal efficiencies approaching 55 percent. And, we believe, 60 percent is an attainable goal within this decade.

Combined-cycle powerplants, using modern combustion turbines, are evolving as the preferred generation technology . . . and one of the best examples of the modern-age high efficiency combined-cycle powerplants is the 2000 Megawatt Futsu complex in Japan.

Fueled by liquefied natural gas, it is the largest, cleanest—and one of the most efficient, large-scale fossil-fueled powerplants in the world.

Korea Electric Power's Seoinchon Plant, currently under construction, is a new, 2000 Megawatt combined-cycle plant. When completed this year it will be the most thermally efficient large powerplant in the world.

This plant is a prime example of how rapidly combined cycle technology can be applied. The overall delivery cycle for this plant was two years from order to construction.

In addition to delivering efficient, cost effective and reliable power through the use of combined cycle applications, impressive results can be also be achieved using gas turbines to re-power old steam plants. This process is currently underway at Virginia Power Company's Chesterfield station where we are converting a 130 Megawatt conventional oil-fired power unit to a 450 Megawatt, gas-fired, combined-cycle plant.

In the new configuration power output will triple . . . without any change in plant size, as all new equipment fits in the same plot that housed the former plant.

In addition there is no increase in cooling-water use . . . and NO_x and SO_x emissions will be substantially reduced, while CO_2 emissions remain virtually the same!

Up until now I've been speaking of combined-cycle systems operating on natural gas or LNG, sometimes with oil as a backup fuel. But combined cycles are not limited to these premium fuels. And in the CIS, even though we perceive significant amounts of natural gas are readily available . they may wish to utilize their large supply of indigenous coal. In this case, combined cycle . . . with its significant efficiency and exceptional environmental performance . . . can prove beneficial.

Integrated gasification combined-cycle power generation . . . or IGCC has also been demonstrated to be effective. One demonstration plant operated successfully, extracting gas from a variety of coals, for 27,000 hours during a five-year period . . . with emissions about one-tenth of those required by regulations.

An IGCC powerplant uses two-stage combustion, with cleanup between the stages. In the first stage, a coal gasifier produces a gaseous fuel. After cleanup, this cod gas is fed to the second stage: the gas turbine of a combined-cycle powerplant.

lGCC is a commercially available technology . . . and we're seeing substantial interest in IGCC around the world.

Overall, advanced combined cycle technology would be able to address the energy needs of the CIS in a very quick and economical manner. For example, a host of small 300 Megawatt packaged powerplants could be quickly placed into operation that would not only address varying regional needs for power but also provide a series of "test facilities," for this technology.

We strongly recommend this course of action in the near future as the best way to take advantage of the "window of opportunity" I spoke of earlier.

Looking at what we we view as the bottom line on the Chernobyl situation . . . the need is great . . . and the time is now to move toward assisting the Commonwealth of Independent States with their clearly precarious energy situation.

Many technologies exist that could address the problems in the CIS and we will be happy to provide those technologies.

Long-term options such as nuclear energy and more immediate technologies such as advanced combined cycle applications stand ready as proven remedies.

What we . . . and other industries . . . require from this body . . . is assistance with handling the political implications of such an endeavor, and we certainly defer to your expertise in this area. Ours is a technology mandate . . . and we have no doubt can deliver in that area. The political mandate falls to you.

We would welcome the opportunity to join forces with the U.S. Government . . . and help in providing the Commonwealth of Independent States with safe, reliable, cost effective energy options now . . . and in the future.

Thank you.

PREPARED STATEMENT OF WOLODYMYR YAVORIVSKY, CHAIRMAN, COMMITTEE ON CHORNOBYL SUPREME RADA OF UKRAINE

CHORNOBYL: ACCIDENT, TRAGEDY, DISASTER

"The aftereffects of Chornobyl, these are in fact the aftereffects of the third world, nuclear war which in April 1986 swept across our long-suffering homeland Ukraine."—Wolodymyr Yavorivsky

The accident at the Chornobyl Nuclear Power Plant, in which only one reactor #4 blew up, is unique in its lasting aftermaths. It led to the greatest catastrophe of the 20th century, and caused the nation-wide disaster in Ukraine.

Geographically tied to the Ukrainian soil, it changed abruptly the lives of hundreds of thousands of people not only in Ukraine, but in Byelorussia and Russia, too. Its aftermaths could be compared to those of the nuclear 3rd world war. Nowadays Chornobyl is not merely a geographical name of an ancient small town in Ukrainian Polessye. It is the word that entered all the languages of the world as a reminder, a warning and a call for joining efforts in wide international interaction in the struggle for survival of mankind.

The tragedy of Chornobyl hit many people. The most horrible is that it affected not only those living now, but also those not born yet. Despite our strenuous efforts this mishap will touch with its black wing the present and the following generations of Ukrainian people and our neighbors on the Earth.

After the Chornobyl accident Ukraine was proclaimed the zone of ecological catastrophe. Five years have passed after the day of this global tragedy. But, despite our enormous and costly efforts, not much was done in the field of study and stabilization of the radiological situation, improvement of health of hundreds of thousands directly affected by Chornobyl. The difficulty of the problem becomes more vivid, its solution gets more demanding economically and technically with time to pass.

The evaluation of the accident's scale and disastrous effects, as well as taking up efficient measures for the minimization of the Chornobyl aftermaths, were considerably hampered by the wrong approaches to the cause of the accident, identification of those who concealed information about Chornobyl.

At the moment of the accident the reactor was operated with constructive defects and it became the main cause of the disastrous development of the accident on April 2, 1986.

The designers of RBMK-1000 reactor criminally neglected the operational regulations:

- Radiation Safety Regulations—8 items;
- General Safety Regulations—5 items.

The report made by Soviet experts at IAEA conference in August 1986 falsely claimed "the initial cause of the accident was an inconceivable combination of violations of operating rules by the reactors' personnel". This interpretation adversely affected the possibility of diagnosing the real cause of the accident at that time.

By the official accounts, 50 megacuries of the most dangerous radionuclides were released to the environment. According to some scientists this figure is much bigger and is about 1 billion curies. The scale of radioactive contamination is very large. The contamination level of 46 per cent of Ukrainian territory is more than 1 curie per square km. Most of the regions of Ukraine were affected, especially the districts of Kiev, Zhitomir, Chernigov, Rovno and Volhynia regions.

5 mln hectares of agricultural lands, 2 mln hectares of arable lands included, were recognized unfit for agricultural production. 1 mln hectares of woods were exposed to radioactive contamination. Most of the timber exploitation areas were closed. The dosed places of recreation of thousands of people, places where mushrooms, berries and herbs were gathered became out of use.

Lasting contaminating of the Dnieper, the source of water for more than 35 mln inhabitants of the republic, took place.

More than 150 thousand people, 60 thousand children included, got an overdose irradiation of the thyroids.

More than 5 mln people, among them 1 mln children, are exposed to intense radiation.

The morbidity of the population increased and the psychological state of the people worsened. 90 per cent of the questioned children touched with the black wing of the disaster are sure they have no future.

The situation shows that despite the measures taken during the past 5 years the problem is still acute.

At the first stages we could not estimate the real scale of the accident, its international, social, economic, humanitarian, ecological, technological and other aspects.

The total damage costs make up approximately 170–512 billion roubles. Most of the long-lived radionuclides accumulated within the 30-km zone from which the people were evacuated.

Nevertheless, the area of more than 45 thousand square km in Kiev, Zhitomir, Rovno and other regions needs urgent environmental protection measures, transition of radionuclides to the farm produce should be lessened, the underground water-bearing strata should be protected, etc.

Natural environment not only accumulated contaminants of the Chornobyl Nuclear Power Plant, but also became the lasting source of contamination of food plants, meat and dairy products, air and weakly protected underground waters.

Researchers defined the spatial areas of accumulation of cesium-137 and migration of radionuclides in the waters of the Dnieper reservoir cascade.

At this time the total amount of cesium-137 in Kiev Reservoir is 7,200 curies, in Kanev Reservoir—2,200, in Kremenchug Reservoir—300.

The increase of radioactive cesium is about 40 per cent per year.

Accumulation of radionuclides also takes place in the deep waters of Dneprodzerzhinsk and Zaporozhye reservoirs.

The ares of cesium-137 were also found in Kakhovka Reservoir and the Dnieper-Bug Estuary.

The lack of a telemetric system of ecological monitoring of the environment in the republic hampers the researches.

The undesirable medical and biological effects of the radioecological situation damage the health of the population, threaten the genetic fund of Ukraine.

Right after the accident 92 thousand people were removed from the contaminated territories of the republic.

It is planned to evacuate still more than 300 thousand people.

The total capital costs of the cleanup program of the Chornobyl aftermaths by the year 2000 make about 20 mln roubles. But the real amount of investments necessary for minimizing the consequences will be still greater.

And all this must be done by economically exhausted Ukraine fighting for its sovereignty.

The most horrible are the genetic consequences of the disaster. 35 mln people in Ukraine are affected or will be affected by Chornobyl. But there are categories of people who need special attention, special medical monitoring.

There are 150 thousand people, among them 60 thousand children, whose thyroid glands were irradiated by the overdoses of radioactive iodine. In the thyroids of 13 thousand children the radiation measures 200 rem, 700—more than 1,500 rem, some dozens—more than 5,000 rem. And the problem of radioactive iodine is still actual. Iodine-131 is found in the analyses of 70–85 per cent of the residents of the contaminated areas and cleanup workers.

There are more than 150 thousand cleanup workers who are dozed with 20 rem or more and now reside in Ukraine.

These are near 2 mln people living in contaminated zones, whose registered level of additional irradiation can exceed allowable stated by the republican concept of living on contaminated territories.

These are evacuees and children born after 1986 by the members of all these groups mentioned above.

Examining the state of health of the residents of the most affected zones, one can observe a tendency for growing and widening of morbidity and mortality rates. The

health of children stirs up serious concern. Compared with the average, the morbidity rate of thyroid diseases in Zhitomir region went up 4 times, and in Narodichie district—6 times. In the affected zones of Kiev region the endocrine diseases morbidity rate grew 3–5 times. On top of that, the scientists stated the growth of pregnancy pathologiesw 1.6–3 times. The same growth is observed in cases of diseases of skin, thyroids, blood, vegetative and vascular systems and inborn defects of newborn children. The scientists ascertain the connection between ionizing radiation doze and immunity worsening. This can be observed in 70 per cent of the children evacuees.

According to the facts the health of adults is damaged, too. There is a growth of morbidity rate in respiratory diseases 1.3 times, blood circulation—1.9 times, gastroenteric—2.7 times, endocrine system—2.1 times, genital 1.8 times. The same is true for the Chornobyl cleanup workers. The disability rate among them grew 1.9 times.

The further problem arisen by the Chornobyl disaster is the elaboration of the concept of further scientific research; working out methods of developing nuclear safety of the "Shelter" unit (reactor #4); localization of highand low-active products accumulated within the 30-km zone and its immediate vicinity; scientific and economic activities in Chornobyl affected zones.

Besides, there is a problem of wastes piled up in the waste storage, the estimated radioactivity of which is tenfold higher than that of the Chornobyl disaster products.

Up to now, there is no unanimous approach to what should be done to secure and localize the fuel and fission products on the "Shelter" unit. There are still problems of how they should be permanently stored (now there are about 800 temporary storages) and what should be done with the equipment and materials assembled in the open-air grounds.

There still exists the problem of decontamination, conversion of radioactive waste, safety of surface and underground waters, recultivation of soil. No tangible results were achieved by the researchers in geochemical and geoelectrical methods of radioactivity elimination. Serious errors were made in the design of drainage screens and water protection installations. The results of the measures for raising efficiency of the purification installations, decontamination posts and equipment, researchers of influence of the fuel substances on man were of minor importance.

Not everything was done in environmental monitoring and forecasting the radiation situation in Ukraine.

The lack of necessary medical equipment, humble steps toward international cooperation caused the incapability of practical medicine to protect the health of those affected. It is not even possible to put them on the register list of those requiring health monitoring.

Taking into consideration the danger of the Chornobyl disaster aftermath—not only for our republic and our country, but for other European countries—the Ukrainian parliament appealed to the governments and non-government bodies of the world community for help in liquidation of this mishap aftermaths.

Some countries and non-government institutions already render humanitarian help to us.

A number of firms is now working out projects for some of the Chornobyl problems solution.

But we think the international help would be most effective in the following areas:

- foreign investments in Chornobyl cleanup programs;
- delivery of medical and scientific equipment, production lines for medical equipment and materials manufacture; production (or co-production) of medicines and medical equipment;
- we will be very grateful for help in rehabilitation of the affected children;
- further cooperation between non-government bodies.

Serious consideration should be given to joint researches of technological, scientific and practical character.

On November 20, 1990 the UNO General Assembly Resolution #A/45/190 "International cooperation in the sphere of mollification and overcoming of the Chornobyl Nuclear Power Plant accident aftermaths" was adopted. Pursuant to Article 2, the General Assembly pled to the UNO bodies, institutions and programs for technical and other specialized help especially to Ukraine. The unprecedented scale of the disaster, its lasting anthrohopogeneous influence on present and future generations should be borne in mind.

Not only Ukraine, but the whole world faces the problems of the Chornobyl disaster. That is why help could be provided by the UNo and its subdivisions, and all the international community to the benefit of all mankind.

The following problems deserve special attention:

- boosting public information campaign about the dangerous effects of radiation;
- training the medical personnel in handling new diagnostic and monitoring equipment;
- low-level irradiation studies;
- training the social workers in rehabilitation of the affected;
- development of new decontamination equipment for agricultural areas;
- purchase of different equipment and materials (especially medical);
- encouragement of joint ventures producing baby-food and high quality equipment for the disabled;
- development of new concepts in housing and housing construction, building materials manufacture, planning and management.

Naturally, we cannot name all the problems, because every day the list of them becomes longer. So the "Appeal of the Supreme Rada and the Council of Ministers of the Ukrainian SSr to foreign parliaments, governments, peoples, international organizations and movements on the 5th anniversary of the accident at the Chornobyl NPP" is very actual now: "Today, once more we appeal to mind, honor and conscience of all progressive people on the Earth, we hope that our appeal will be apprehended with understanding, that international solidarity in the liquidation of the consequences of the Chornobyl catastrophe will continue and strengthen. WE all will use our knowledge, wisdom and goodwill in joint and concrete actions to the benefit of present and future generations, for the sake of life on the Earth".

We will recur again and again to the date of 26th of April 1986. And so will do our grandchildren and greatgrandchildren, their children and their grandchildren.

Chornobyl not only divided the lives of many people into "before" and "after". It marked the beginning of the new times.

And we must always fall back on Chornobyl experience. One of the main lessons of this tragedy is: we have to think twice before making any political, economic or technological decisions, and we must be ready for the worst in order not to turn the bread-basket into a radioactive waste-basket.

We simply must think whether it is really necessary to coerce the nature, to fight it? Is it not better to live in harmony with it according to its eternal laws.

We are all one people. And we have common tragedies. We express our heartfelt gratitude to the world community for the concern in our disaster. The Ukrainian people will always remember the helping hand of every man and every nation, purity and nobility of their thoughts, their charity in the times of our terrible ordeals.

Don't bid us—Ukrainians—farewell.

We are still alive.

Statement of Friends of the Earth

RUSSIAN ROULETTE: NUCLEAR POWER REACTORS IN EASTERN EUROPE AND THE FORMER SOVIET UNION

I. INTRODUCTION AND EXECUTIVE SUMMARY

The question of what to do with the dozens of aging, dangerous and understaffed nuclear power reactors in Eastern Europe and the republics of the former Soviet Union constitutes a major public policy dilemma. These extraordinarily risky facilities urgently need to be closed down. They pose imminent threats to public health and the environment, both locally and globally.[1]

This Report has been prepared to address this dilemma. It is being released by Friends of the Earth-International (FOEI) for use by the G–7 countries, the countries in Eastern Europe and the former Soviet Union, as well as by the World Bank, International Monetary Fund, Bank for European Reconstruction and Development, and the international Atomic Energy Agency. All of these agencies have looked at the issues, but they are not proposing the urgent actions necessary to responsibly protect the public. Their proposed solutions involve short-term investments in training and longer-term investments in the reactors themselves, possibly including building containment shells around some reactors. This is a short-sighted approach, which will neither protect the public nor be cost-effective.

The question of what to do with these nuclear reactors is an Important hem on the agenda of the G–7 Economic Summit, which takes place In Munich, Germany

from July 6–8. Because the Governments and their advisors at the World Bank, IAEA and other agencies have not developed action plans that are commensurate with the risks to the public, Friends of the Earth has compiled this Report.

To help Eastern European countries and the republics of the former Soviet Union prevent further major nuclear disasters, the G–7 countries and their agents should:

1. Immediately [2] help close down fifteen nuclear power reactors of the Chernobyl type (RBMK), sixteen reactors of the early pressurized water type (VVER 440/230), and eight second-generation pressurized water types (VVER 440/213) by providing the direct assistance of western teams of scientists and engineers and financial aid.[3] The Immediate closures should include:
   - all fifteen RBMK reactors in ClS and Lithuania;
   - all ten VVER 440/230 pressurized water nuclear plants In the CIS;[4]
   - four reactors [5] at Kozloduy (Bulgaria);
   - all eight existing pressurized water nuclear power reactors In the CSFR;[6] and
   - Paks (Hungary) reactors 1 and 2.[7]
2. Through investments of at least $10 billion, mobilize and fund safe energy alternatives in the region during the next five years, focussed on the reduction of waste in the industrial, household, and transportation sectors, as well as on immediate steps to invest in safe and sustainable energy.
3. Rapidly replace 50 percent of the power generated by the nuclear power reactors with "supply side" options, including rehabilitation and better use of existing thermal powerplants and quickly installed gas turbine combination co-generation plants. If the goal were to provide approximately 12,000 MWe through gas turbine combination go-generation plants, this would require an estimated investment of about $8 billion.
4. Assist in developing energy strategies for each country whose fundamental principles include:
   - closure of all remaining nuclear power reactors as soon as possible, but within five years;
   - rapid reduction of pollution caused by outdated solid fuel use;
   - a comprehensive energy efficiency approach; and
   - policies to foster the development of safe and sustainable energy for the long-term.

Based on currently available information, the G–7 intends to spend about $800 million in aid money on improving the existing nuclear power reactors rather than rapidly phasing them out. This approach seems to be based upon four main objectives:

1. To reduce the risks of nuclear accidents;
2. To decrease air pollution by replacing old lignite and coal powerplants, rather than nuclear plants;
3. To create projects for Western companies specialized in nuclear power that face a lack of contracts in the West;
4. To prevent a further loss of public support for the nuclear option (including existing nuclear investments) in both Western and Eastern countries.

FOEI supports the first objective, but it advocates an alternative approach to risk reduction—the closure of all nuclear power reactors in these countries, beginning with the most dangerous, and rapidly phasing out the remainder.

This approach requires immediate investment in energy conservation and the development of safe energy supplies, involving both electricity generation and measures to induce different decisions by end-users of energy. Increases in "usable" electricity should be followed by the prompt closure of the remaining reactors, on the basis of risk posed by a particular facility.

The closures of all the nuclear power reactors should be sponsored by the G–7 countries on the basis of GRANTS: since the closures themselves will not yield profits, lending money to dismantle these nuclear facilities would further deteriorate the financial positions of these countries.

The second objective of the G–7 Governments should be met not with nuclear energy but with a decrease in the energy intensity of these economies. At this moment the energy use/GDP of Hungary is, for example, 3.91 times that of the European OECD-countries. The other countries are similarly energy-inefficient.

It is folly of the highest order to follow the third and fourth objectives of the G–7 Governments. Instead, all efforts in the energy sector should be focussed on demand reduction and the provision of safe and clean supplies. Trying to support their own nuclear industries means that the G–7 countries will be wasting their own citizens' money and risking disasters which can be avoided.

The G–7 Governments are presented with an unprecedented opportunity to invest in life-sustaining rather than life-threatening options in the Eastern countries. By

taking forceful steps to help close down the dangerous nuclear facilities in the East, the G–7 Governments would demonstrate their empathy with populations suffering the impacts of Chernobyl and other nuclear accidents. In addition, the Western nations would be helping to secure their own well-being by avoiding the possibility of a second Chernobyl. The closures that FOEI is recommending should be facilitated by teams of western experts—from the government, non-government, scientific and private sectors—working in close cooperation with scientists, engineers and non-governmental experts in the Eastern countries.

II. REACTOR SAFETY

A. Overview

All Soviet-designed reactors present a serious and imminent threat to environmental stability as well as to human health. They pose the following threats:

- Ill-conceived reactor design, the legacy of poor Soviet technology, presents serious risks of accidental leaks or explosions, both major and minor;
- Poor worker training and morale risks serious errors on a day-to-day basis;
- Inadequate capital undermines the ability of plant operators to maintain minimum safety standards; and
- The lack of uniform regulation and standards for waste disposal results in hazardous disposal and handling of radiation and radioactive waste.

B. Reactor Design

The Soviets used two basic reactor design concepts: the RBMK graphite reactor, of the type found at Chernobyl; and the WER pressurized water reactor, of which several generations have been developed. Each model has unique flaws which pose different safety risks.

1. The RBMK

The RBMK poses such severe, intractable risks that Adolf Huttl, head of the Nuclear Energy Division of Siemens International (once one of the world's biggest constructors of nuclear plants), has rejected the possibility of their upgrade, stating: "The only answer is to shut them down as soon as possible." [8] This view has been echoed by Mr. Klaus Topfer, Germany's environment minister.[9] The consensus of the nuclear community comes down against the continued operation of the reactors. Some of the major design flaws include:

- Positive reactivity feedback: As the reactor operates at lower power levels, the fission reaction accelerates. Therefore, in the event of low power operation, even the act of shutting down increases the risk of a serious accident.[10] In addition, the flammability of the graphite moderating agents intensifies the risk of a catastrophe from either an emergency or a common-cause failure.[11]
- The reactors have no containment vessels to lessen the impact of radiation leaks, or protect the surroundings in the event of a core meltdown.[12]
- The fuel channels critical to the safety of the reactor have a history of rupture.[13]

It is important to note that even with upgrades, the RBMK will not meet Western safety standards, according to Huttl and others in the nuclear community.[14]

The problems of these reactors are far from solved, as the March 24, 1992, accident at Sosnovy Bor illustrated. In that case, radiation leaked out from an RBMK reactor outside St. Petersburg, Russia. On the international scale of seven, the leak was first given a three (the Chernobyl meltdown received the highest rating of seven).[15] The enigmatic accident disconcerted some in the scientific community. Because RBMK design information has been "closely guarded by the Russian nuclear bureaucracy," [16] knowledge of RBMK design is not complete in the nuclear community.[17] This poses additional problems for their backfitting. Western experts will be backfitting a plant of which they have, at best, only a theoretical understanding.

2. The VVER 440/230

Of the VVER pressurized water reactors, the first generation model 230 poses by far the most serious set of risks. According to the IAEA, "These units clearly do not meet current safety requirements." [18] The major deficiencies [19] include:

- The lack of a containment vessel increases radiation release risk. Adding to this deficiency, the absence of a pressure relief system impairs the plant's ability to respond to an emergency, while the reactor vessel's embrittlement, present at almost every site, increases the risk of radiation release. In fact, at some of the older reactors at Kozloduy (Bulgaria) and Bohunice (CSFR), the reactor vessels have a high copper content, which accelerates their embrittlement further.[20]

• Inadequate redundancy and separation of emergency safety equipment hamper the reactor's ability to respond to day-to-day abnormalities and increase the chance of common-cause failures. The very design of safety systems ignores the possibility of common-cause failures. These oversights are particularly dangerous, because components of the 230 have been historically unreliable.

• Insufficient emergency core cooling capacity limits the reactor's ability to head off a core meltdown. The system lacks separation and redundancy. The lack of separation allows the system to be almost entirely destroyed by a localized fire or accident. The lack of redundancy makes it susceptible to simple malfunctions. Similar problems plague the electrical system and other control systems.

• Inadequate control panels and systems put the operator at a disadvantage. Poor monitoring of the power distribution inside the core presents unique problems for the 230, because its safety is based on the principle of high core margins of safety, which in turn depend on the ability to maintain a safe distribution of power.

• Substandard materials and substandard construction techniques, imported from the USSR, affect this reactor. (The former Czechoslovakian nuclear community claimed to be free of this problem, by virtue of their "high-quality" domestic materials. However, the nation's nuclear safety authority, CSKAE, has consistently disagreed.) For example, an investigation of the East German 230's revealed that the continually poor quality of materials imported from the USSR "impaired the standard of maintenance work in the past." [21] Such cumulative damage cannot easily be undone.

• Inadequate fire protection increases the risk of radiation release. On this count, however, the large water inventory, compared to other PWRs, partially compensates.

Backfitting the 230 poses further risks. In order to upgrade the emergency core cooling system, the primary circuits and shielding must be pierced by new pipework, which will then create a new site for radiation release.[22] In addition, the poor construction of the reactor subsumes the process of backfitting, because the reactor itself was badly built. Only a complete reconstruction could solve for this problem.

Finally, judging from the German experience, backfitting will be far too costly, and may well be impossible. To backfit the four 230's at Grelfswald1 the German government would have had to spend an estimated -.8 billion. Not surprisingly, the project was abandoned due to cost.[23] If the plants throughout Eastern Europe and the former Soviet Union are fully upgraded to acceptable safety standards, a similar price tag should be expected. More frighteningly, the Greifswald investigation revealed that: "The risk of a catastrophic failure of the reactors' pressurized containers cannot be alleviated by means of additional fittings and technical modifications." [24]

3. The VVER 440/213

The next generation of Soviet pressurized water reactors—the 213—corrects some safety deficiencies, but still falls short of Western standards.[25] According to John Willis, in his report on VVER backfitting,[26] this model has several major design flaws.

• Although an improvement over the 230, the core cooling system Is still between 10 to 50 times less reliable than contemporary Western systems.

• Even this, the second-generation model, does not have a containment system. Therefore, there is a much higher risk of radiation release.

• The pressure redirection system's reliability remains questionable. Furthermore, even if it succeeds in relieving pressure, a consequent radiation release is likely.

• The model shares the 230's problems with embrittlement, redundancy, fire protection, and substandard construction techniques and materials.

The IAEA and others in the nuclear community apparently believe that this class of reactors can and should be backfitted to meet Western safety standards. Estimates for a long-term backfitting program range between $6 billion and $20 billion, with the median estimate at $10 billion.[27]

This is a high price to pay, given the inherently risky nature of backfitting. Just as with the 230, backfitting risks the creation of new radiation release sites and fails to solve the problem of shoddy workmanship omnipresent in Soviet-built nuclear facilities. The German experience with the 213 provides some indication of the potential for backfitting. Germany's Klaus Topfer has said that the 213 located at Greifswald, in the former East Germany, has "no future in Germany.[28]

4. The VVER 1000

This reactor, designed in the early eighties, represents an improvement [29] over the model 213; however, it too conforms only to "the international standards of the

late seventies." [30] Although the VVER-1 000/320 reactors have a type of containment vessel, it is more vulnerable in an emergency than Western-designed containment vessels. All of these containment vessels have holes to permit various materials into the reactor area (water, fuels, etc.). For example, the outlets for the piping system are tunnels through the concrete that extend some distance from the containment vessel about three meters above ground level, placed on columns. These are easily damaged in an earthquake or other "event" and practically mean disruption of the containment's integrity. In general, the containment shells are 1.2 meters thick, made of steel reinforced concrete.[31] Other notable problems are:

- Its pressure vessel diameter presents a special disadvantage: because of its small size, it provides an inadequate buffer of water between the neutron bombardment afforded by the fuel and the vessel wall. As a result, embrittlement accelerates.[32]
- A fundamental construction error in the reactor core causes this reactor, like the RBMK, to exhibit positive reactivity feedback at certain operating levels. "To date no practicable solution has been found to this problem."[33]
- The plant layout results in fire hazards, threatening to the safety of the installation.[34]

C. The Culture of "Acceptable Risk"

The Eastern bloc nuclear industry sprang out of the vast Soviet military-industrial complex. Therefore, many Russian politicians argue that the industry retains a utilitarian disregard for human life and well-being.[35] This attitude manifests itself in the culture of acceptable risk. Nuclear plant workers and operators simply do not recognize the need for the level of safety that is taken for granted in the rest of the international nuclear community. This attitude must be taken into consideration in evaluating proposed technical backfits, as the mindset of most operators will probably undervalue safety considerations in the day-to-day operations that will determine the long-run safety of the plant. This carelessness appears on many levels of the nuclear community.

Plant workers, especially since the advent of political instability, have been characterized by a notoriously poor attention to detail and shoddy operating procedure. In the model 230's, for example, the IAEA found a poor "safety culture". "Safety culture embodies a top to bottom approach to plant operation from a safety perspective and needs to be promoted." [36] However, demoralized plant workers do not spend the time necessary to maintain a mechanism as sophisticated as a nuclear plant. Workers among operators of RBMK reactors suffer from declining morale, according to the United States Nuclear Regulatory Commission, because the plants, which do not receive adequate replacement investment, appear to be on the way out.[37]

For example, Lithuanian safety inspectors argue that the RBMK plant in Ignalina, Lithuania, is run in complete violation of national safety standards. As a result of shoddy workmanship, plant personnel ignored standard operating procedures, and consequently exposed three wofflers to dangerous doses of radiation.[38] According to one Lithuanian safety inspector, this situation has been created, because the nuclear bureaucracy has ignored the "human questions", and has treated its workers poorly.

". . . it is not a crazed 'atomic lobby' sitting behind the instrumentation panel in the various [plants]; they are normal people. . . And if society seriously wants to have safe [plants] it is essential to resolve urgently not only the technical questions but also the purely human ones. There should [be] no instance of a reactor operator who brings home to his family a salary which is less than a tenth of what an average secondhand dealer earns. . . Is it still not clear that one has to pay for safety? And pay handsomely for the miser pays twice. . .[39]

A similar, in fact much worse, situation prevails in the Bulgarian plants, none of which are RBMKs, at Kozloduy. Because Russian technicians have returned home, and Bulgarian technicians have left their poorly paid jobs and poor living conditions, the plant has suffered a massive brain drain. In addition, the plant's technology itself (four model 230's and two model 1 000's) lacks adequate safeguards of its own. Therefore, the loss of trained personnel becomes particularly problematic. These problems have led nuclear experts to call this plant "one of the most dangerous nuclear powerplants in the world." [40]

A recent study of the plant by the Cousteau Society revealed poor inspection and a severe lack of spare parts.[41] The need to operate plants at high capacity, as well as the lack of domestically manufactured spare parts have hurt efforts to maintain the plant. A member of the Cousteau team, Dr. Robert Pollard concluded: "There is essentially no dispute that Units 1-4 at the Kozloduy nuclear powerplant do not

meet many of the current safety standards that are considered to be the minimum requirements needed to protect the health and safety of the public." [42]

Nuclear bureaucracy presents a further problem, as the agencies responsible for inspection, compliance and maintenance of investment. For example, In February, the Russian government halved its number of nuclear Inspectors. Less than two months later, the accident at Sosnovy Bor was blamed on poor testing and inspection. ". . . the nuclear inspectorate . . . is in chaos and strapped for cash. In a country where making electricity has always come before safety, the inspectorate has never been properly independent of the energy ministry." [43] Obviously, the funding situation is unlikely to improve in the short- to medium-term, while the government's prioritization of electricity before safety may be far harder to eradicate.

RBMKs are not the only plants that lack sufficient replacement parts. Across the board, "the supply of spare parts dwindles." [44] Even with more funding, there is no guarantee that the mindset of the bureaucracy will change; in fact, an attempt to reorder priorities must run into some recalcitrance, because it challenges values people have acted on throughout their careers.

Nuclear experts share this dangerous devaluation of safety, as a recent accident demonstrates. After the leak at Sosnovy Bor, Western nuclear scientists observed that the incident, though not severe, had caused significant fuel assembly damage. However, Russian experts simply noted that the reactor safety systems had performed admirably, and showed the success of the design.[45] Evidently, Soviet-trained scientists are more concerned about serious meltdowns, and less concerned about radiation release, even with its concomitant health risks. This, however, is not simply a matter of "education" or "re-training", because it once again reflects the significantly different priorities of the Soviet nuclear community. It is unlikely that these scientists do not know the health risks; rather, they do not value them. Training cannot remedy such a difference in outlook.

Nuclear waste disposal is currently carried out, as it has always been, in a manner that threatens the health of the environment. In particular, the nuclear nations of Eastern Europe face a unique problem: although in previous years, the Soviets accepted and reprocessed their wastes for no charge, in recent years, the Russians have begun to charge for the reprocessing. The young nations argue that they cannot afford this cost. To complicate further their waste disposal procedures, In 1990 the Russian Parliament proclaimed that no nuclear waste from other republics or nations would be buried In Russia. In response, these countries have begun storing irradiated fuel in temporary storage facilities, which will remain available for approximately five more years. The countries plan to expand their permanent storage capabilities, but they face a public that has lost confidence, given past burials of radioactive materials.[46] Not only is space for waste disposal finite, but it seems that capacity in those countries has been exceeded, as popular pressure brings itself to bear against the construction of new facilities.

The nuclear related activities of the former Soviet Union have resulted in severe environmental damage, leaving the young republics little room for error. Some of the worst damage occurred because of illegal disposal of nuclear wastes in the ocean. According to Oleg Petrov, Chief Radiologist of the Soviet Navy, the former Soviets used to dump low- to intermediate-level waste at sea. Several nuclear warheads have been lost at sea, in addition to those on board two sunk submarines.[47] Because of the level of dumping and leakage, damage has been caused to the delicate Arctic environment.[48] The situation has become so bad that many lakes and rivers in the former Soviet Union have become dangerously radioactive.[49] The Russian Government plans to take steps to remedy these problems. People's Deputy Vorpholomeev, who chairs the committee on Ecology and the Rational Use of Natural Resources, claimed that radioactive waste is currently the most serious environmental problem in Russia.[50]

Even in a group of legislators that is relatively concerned about these issues, however, recalcitrance from the nuclear community, both bureaucratic and scientific, as well as the vast extent of environmental damage to date, hinder the ability of the state to solve for the hazards associated with nuclear waste and leakage. Every day that a reactor continues to operate compounds the problem by generating new waste and new environmental radionuclide contamination. If the reactors are not shutdown, the republics and the countries of Eastern Europe will not be able to deal effectively with their extensive levels of pollution.

Shoddy documentation of materials was common during the reign of the Communist regime, because paperwork was valued less than fast energy production. As a result, it is difficult to determine the original construction materials used in the re-

actors; this information gap makes inspections and backfitting particularly difficult, if not impossible.[51]

III. NUCLEAR POLITICS [52]

Accompanying the development of a dangerously inefficient bureaucracy has been the formation of public hostility toward the further development of nuclear power. This hostility combines with the recalcitrance of the bureaucracy to render nuclear power ultimately unworkable. This reasoning is particularly compelling since fundamental attitudes toward nuclear energy are likely to transcend the short-term, as has been the case in other nations, and thus are likely to affect the long-term future of the industry and the nature of any regulation.[53]

A. Eastern Europe

1. Bulgaria

In February 1990, opposition among 40,000 citizens led to the formation of an anti-nuclear lobby, which resulted in the cancellation of the construction of a second nuclear reactor in Belene. In addition, expansion of the Kozloduy plant was canceled, under public and international pressure.

2. CSFR

Funded by a German utility company (RWE), the construction of a new VVER 1000 in Temelin continues. A condition of the contract apparently is that power be exported to Germany starting in 1995, and it is possible that RWE may take an equity position in the new facility because more investment is required. Information about the precise situation at Temelin is difficult to obtain. Recently engineers at the construction site discovered that the reactor was missing some equipment and so they broke a hold about 4x5 meters in the containment vessel in order to make the necessary repairs. This hold in the containment was then repaired. Prime Minister Petr Pethart tried to find Western support to stop construction of the Temelin reactor in the spring of 1992.

Public opinion in CSFR remains sharply divided, and the growing anti-nuclear movement receives wide media coverage for its protests at all of the nuclear facilities. Recently, the public mobilized to prevent the construction of a temporary waste storage site in Dukovany.[54] In another incident of opposition, the people of the Slovakian town of Kosice successfully blocked the construction of two VVER 1 000's in the town of Kecerovce.[55] This sentiment has spread to the government: in June, 1991, the environmental minister of CSFR joined the protest against the expansion of nuclear power in his country. His position reveals a deep rift within the government on the issue of nuclear power.

Austria, in support of a nuclear-free Central Europe, is uneasy with the presence of nuclear reactors in CSFR. Earlier, Austria offered CSFR 400 MW of free electricity in exchange for the closure of the NPP Bohunice reactor that borders Austria, but It is doubtful if this offer is still on the table. In addition, the Austrian Ministry for the Environment is paying for a study of energy saving possibilities. It was begun this year by the Prague-based SEVEn Institute and the Austrian Energieverwertungsagentur.

3. Hungary

As the revolutionary government came to power in Hungary, freezing construction of new nuclear reactors was an initiative of portions of the government. The expansion of nuclear reactors in Paks appears to have been halted, and the planned construction on the fifth and sixth reactors has not taken place. These developments parallel the gains of Hungarian environmentalists, who played an important role in the Hungarian political scene, both before and after the revolution.

B. Former Soviet Union

Opposition toward nuclear energy in the former Soviet Union stems from a distrust of the "nuclear establishment" [56]—a distrust expressed through the protests of a large portion of the public against the further expansion of nuclear energy. The nuclear establishment, a 1powertul and privileged class" [57] in the former Soviet Union, symbolizes the old order to the average citizen. The distrust directed against the nuclear establishment is representative of the distrust toward the old order, which collapsed under its lack of credibility.[58]

The nuclear establishment is dominated by members of the technical community, which denies that nuclear energy poses a real threat and "stresses that nuclear is better than the realistic alternatives." [59] Despite such claims, the opponents of nu-

clear energy have been able to block the further expansion of the industry sought by the nuclear establishment.

However, on March 26, 1992, the success of nuclear opponents was upstaged when the Russian government decided to "resume construction of a number of new nuclear plants and to increase the capacity of existing ones." [60] Nevertheless, that decision seems to have been motivated not by the support of the public, but by the government's perception of a need for nuclear energy. In fact, a recent referendum on the construction of the Bashkir nuclear station in Russia showed 99 percent of the voters opposed to the plant. As a result, President Boris Yeltsin has promised that it will be converted to natural gas.[61]

An additional factor, the accident at Chernobyl has aroused a prevailing fear among Ukrainian citizens, whose support has strengthened the anti-nuclear movement. Protests have occurred at many nuclear plants, in particular at the Khmel'nitskly plant. Not surprisingly, the Green party has also recently been gaining popular support.

Public hostility will not go away even if the bureaucracy cleans up its act, since public mistrust will be slow to change—for good reason. This strong public opinion and current bureaucratic inefficiency undermine the nuclear optimists' vision of the future workability of nuclear power. Even in the presence of massive infusions of Western funding, the potential for the "success" of nuclear power in these countries remains highly questionable.

IV. ENERGY ALTERNATIVES

A. Long-term Energy Strategies

This proposal aims not simply at the replacement of nuclear-generated electricity by conventional sources, but rather at the development of long-term energy strategies designed to erase the dangerous dependence on nuclear energy and foster the use of safe, sustainable energy. The goal of an energy strategy should be to use safe primary energy most efficiently, in order to alleviate the need for dangerous primary energy. Therefore, conservation should aim not only at electricity savings, but also at savings in the total consumption of primary energy sources. Given that electricity itself is ultimately generated by the consumption of primary energy, the conservation of conventional primary energy frees up resources to be used in the replacement of nuclear-generated electricity. In this way, the consumption of primary energy connects intimately to the consumption of electricity.

For safe primary energy to be used most efficiently, it may indeed be necessary for electricity consumption to stay constant or to increase, because in many areas (such as in certain areas of the transportation sector) consumption of electricity is more efficient that direct consumption of a primary energy source. However, this does not conflict with the goal of replacing nuclear power; rather, it suggests that the structure of energy production and use will have to shift if efficiency is to be maximized. A sound energy strategy, then, may well involve the diversion of primary energy sources to the generation of electricity, and the subsequent construction of alternate generation facilities.

One possible policy solution would be a tax on any primary energy consumption (especially oil) found to be less efficient than electric alternatives. The revenue collected could be used to fund the construction of new generation sites for electricity.

B. Eastern Europe

As a percentage of electricity produced in 1991, nuclear power accounts for 28.6 percent in CSFR, 48.4 percent in Hungary, and 34 percent in Bulgaria.[62] However, the situation in the energy market remains fluid, and opportunities for short- and long-run substitution exist.

1. Market Reform

As energy markets throughout Eastern Europe become liberalized, prices will rise until they match international levels. In Hungary, those levels have already been matched in coal, oil, gas, and heat markets.[63] CSFR currently pays international market prices for imported oil, and has targeted 1995 as the deadline for the full elimination of all subsidies, direct and indirect, paid to the energy market.[64] Bulgaria has increased prices to world levels, and has begun to restructure state ownership of the energy industry, even going so far as to privatize the natural gas industry.[65]

As power becomes more expensive, the quantity of power demanded will decrease. However, the extent of the decrease depends on the responsiveness of quantity demanded to price (in economic terms, the price elasticity of demand). This responsiveness depends on the ability of final consumers to implement conservation measures.

To encourage this implementation, businesses and individuals need access to conservation information and conservation technology.[66] In economies which valued energy consumption as a symbol of progress, and conservation as a symbol of poverty, it is unreasonable to assume that consumer of energy possess the means to improve their energy efficiency. As a result, international assistance is needed to encourage conservation and provide the technology necessary to save energy.

2. International Assistance

Governments and international agencies must disseminate information about conservation technologies, as well as the benefits of conservation. Technologies such as compact fluorescent light bulbs and improved insulation of pipes and buildings represent just a few of the vast number of efficiency technologies available for use.[67] A study by the US AID (Agency for International Development) lists many simple and cost-effective measures for Eastern European industry.

Some low-cost, quick payback measures frequently recommended for the plants studied by AID include: continuous oxygen analyzers for stack gas analysis; infrared thermometers for the identification of heat loss sources; heat meters; steam flow meters, leak detectors, and steam traps; electric power demand diagnostic equipment; other diagnostic equipment such as pressure recorders, thermometers and humidity meters, industrial stethoscopes, and gas flowmeters.[68] Observe that much of this equipment is diagnostic: many plant operators do not know when, where, or if they are wasting energy.

The study further lists some energy efficiency improvements: energy-efficient lighting and control systems; high-efficiency gas and oil burners, and automatic control systems for existing and future boilers; energy management control systems for commercial and industrial use; high efficiency refrigeration systems; electricity demand management systems; industrial pipe insulation; condensate extraction boilers; incinerators which include heat recovery units; waste heat boilers; variable speed controls installed on electric motor drives.[69]

As a further measure, governments could set standards for energy efficiency. Although this would increase the cost of domestic production, that rise would be countered by the increase in foreign marketability of products; in turn, increased exports could help offset the initial jump in fixed cost from improved design.[70] In addition, the savings in energy use will be particularly significant, given the especially wasteful design of Hungarian products.[71] As a final possibility, Hungarian utilities could follow the example of US utilities, by directly investing in efficiency. Pacific Gas and Electric, for example, the United States' largest private utility, estimates that it can get three-quarters of Its additional power needs over the next decade through efficiency gains as simple as improved insulation, replacement of incandescent bulbs with fluorescent versions, and cogeneration technology.[72]

Energy could also be saved in the transportation sector, which is likely to experience a great deal of growth with the advent of increasing economic liberalization and expanded productivity. If public transportation is not supported now, it may be shut out in the future, as rapid economic growth may fuel the rise of the personal auto. To encourage the development of efficiency in this sector, public transportation should be provided, and energy efficiency standards should be applied. These standards should penalize polluters; low energy efficiency should be taxed for the cost it exacts from the environment.[73] By substituting for nuclear power without increasing emission levels, conservation also avoids contributing to the high levels of pollution already experienced throughout the region.

3. Particular Opportunities in Hungary

a. The Impact of Waste Reduction

Just as the other economies of Eastern Europe, Hungary wastes tremendous amounts of power. Although it produces a mere quarter of Japan's output, Its per capita energy consumption equals that of Japan.[74]

As is the case throughout Eastern Europe, Hungarian industry uses a significantly larger portion of total energy production, in comparison to the other industrialized nations, both because Hungary harbors a disproportionate amount of energy-intensive heavy industries, and because its industries use energy inefficiently. Market reform has begun to solve the first problem;[75] in 1990, heavy industrial output declined by 10 percent and continued to decline in 1991. This trend has played a role in decreased energy demand, which fell 7 percent in the first 9 months of 1991. The government has estimated that this restructuring will account for two-thirds of the total reduction in energy intensity, while efficiency will have to account for the remaining third.[76] The emerging unemployment can be turned around

in part through the stimulation of sophisticated, less energy wasting branches of the Hungarian economy.

Several studies have confirmed the various opportunities for energy savings. An assessment of the district heating network in Budapest suggest network energy losses between 30 percent and 40 percent. Such losses could be offset by upgrading heat distribution networks and developing small-scale cogeneration units in powerplants.[77] A 1990 study by Thomas Jaszay for Pacific Northwest Laboratory demonstrates that Hungary can develop 700 MW of cogeneration capacity in the near term, with 600 additional MW available by 2005. Since the Paks stations have an effective capacity of 1425 MW,[78] over the long-term,[79] this represents a replacement of 49 percent in the short-term, and 91.2 percent in the long-term. A 1988 EEC study corroborates Jaszay's analysis, by arguing that "efficiency could provide the same net increase in energy as a new nuclear power reactor, but do so far more quickly and at about one-fifth the cost." [80] Considering that new nuclear power reactors produce 2 to 3 times more power than Hungary's older, smaller capacity stations, this claim seems particularly dramatic.

Jaszay's study further argues that final energy demand in Hungary will actually decrease in the coming years, from 1355 PJ in 1990, to 1269 PJ in 2005, and finally to 1117 PJ in 2030. Therefore, after the installation of cogeneration through 2005, the remaining 125 MW (3.94 PJ) [81] would be solved for by a decrease in energy demand, which will total 152 PJ, fully 148 PJ more than necessary. In fact, since Hungary's nuclear output in a year comes to just under 41 PJ, conservation alone could solve for the energy crunch well before 2005. To further bolster the case for efficiency, Jaszay now believes his estimates to be too conservative.[82]

b. Trends in Supply

Although demand will continue to fall, supply likely will follow suit. Production throughout Hungary's energy industries has been falling over the past few years, as Hungary has become increasingly dependent on energy imports.[83] Although nuclear power would seem then to be an effective solution, it turns out to lack economic viability.

Since Hungary is prepared to integrate itself into the international economy, in order to preserve a reasonable balance of trade, it must maximize the efficient utilization of goods which it imports, while maximizing domestic production. A strategy of energy conservation matches the first objective, and will minimize the outflow of hard currency for energy imports. Nuclear power, however, does not match the second objective. First, much capital must be imported in general to maintain the Paks nuclear plant, and much more will obviously have to be imported to upgrade it to acceptable safety standards. Any capital expenditure associated with these loans is capital which cannot be spent as part of a larger national conservation strategy.[84] Second, since Hungary is a net energy importer, it is unlikely to be able to export nuclear-generated electricity for foreign exchange. Therefore, if it costs more to produce nuclear energy than it costs to import energy, then economic resources, which could be spent upgrading Hungary's ancient and wasteful energy infrastructure, are being wasted.

Because investments in efficiency have been found to be one-fifth to one-seventh the cost of nuclear electricity in Hungary,[85] both precious hard currency and scarce domestic capital could be far better spent on efficiency than on nuclear power, particularly in the next decade, when efficiency improvements are likely to be easiest and have the highest payback (when energy efficiency approaches international norms, investment will have a lower return). For the long-run, as efficiency improves over time, so does conservation technology. For example, in the long-term, Hungary may increase its cogeneration capacity even more;[86] in addition, its economy will certainly become less energy intensive, as it switches away from heavy industry, which will necessarily become less profitable if Hungary needs to import energy by using valuable foreign exchange. Finally, in the long-term, Hungary's existing nuclear reactors (the already outdated VVER 440/21 3s) will also cease to be able to function. Therefore, it will not be difficult to fill in the short- to medium-term void left by the closure of these reactors.

4. Particular Opportunities in Bulgaria

In 1991, nuclear plants in Bulgaria accounted for 34 percent of electricity produced.[87] This figure includes the 2025 MW of effective generating capacity (out of 2722 MW of net generating capacity).[88] However, Bulgaria poses a more extreme form of Hungary's problem, because Bulgaria is "the most energy import-dependent country in Eastern Europe. . . It imports almost 60 percent of its energy needs, including virtually all of its oil and natural gas. Most of the country's domestic energy

production is solid fuels, either brown coal or lignite, while 36 percent of its electricity comes from nuclear energy." [89]

Bulgaria has already closed its two oldest nuclear power reactors temporarily, but has argued that it needs the power from the remaining four.[90] Because of Bulgaria's unique dependence, its reactors could be phased out a little more slowly than in other nations. Its two oldest, currently operating reactors, both model 230's, contribute an effective generating capacity of 659 MW, (the two closed reactors normally contribute 604 MW) while its two new reactors, still three to four years from peak production, have a total capacity of 1906 MW.[91]

Like the other nations of Eastern Europe, Bulgaria uses more energy than other OECD nations per unit of output, according to World Bank statistics: Bulgaria is five times more energy intensive than the former nation of East Germany, and more than twice as intensive as the OECD average.[92] Data from the AID study shows that emergency energy assistance to Bulgaria in the past has saved considerable amounts of energy. Considering improvements to only three types of facilities (iron/steel mills, poultry slaughterhouses, milk factory), the investments in approximately 10 plants [93] resulted in an estimated net savings of $184,761 [94] per year; for each investment, the simple payback period was just three and a half months. A total of 2580 TOE, or .116 PJ was saved over just a few facilities.[95]

Further, the costs of choosing nuclear power over a strategy emphasizing energy-efficiency increase substantially in the case of Bulgaria, because its Kozloduy station is in exceptionally poor operational and structural condition.[96] The poor management practices prevalent at that nuclear installation dictate a switch to increased efficiency at other power facilities.

The current economic contraction in Bulgaria poses an unparalleled opportunity to restructure patterns of energy production. Since 1988, electricity consumption has fallen from 49.2 billion kWh (49,200 GWh) to 40 billion kWh (40,000 GWh). These trends should continue until the middle of this decade.[97] As a result, in the encouragement of renewed consumption, industry can focus on energy efficiency, which can enable the economy to produce more, at less cost, without waiting for expensive increases in energy output.

5. Particular Opportunities In CSFR

a. Conservation Potential

CSFR nuclear plants produced 2717 MW (23.8 TWh, or 85.68 PJ [98]) in 1991, or 29.4 percent of that nation's total electricity.[99] Unlike Bulgaria and Hungary, CSFR produces 70 percent of its own energy. In addition, its economic restructuring has proceeded very rapidly: although prices are still centrally determined by the two republics, the prices charged to industry reflect international prices.[100] This increase in prices will be particularly effective, because industry consumes 50 percent of all energy.[101] Since industry will be especially cash-starved over the next few years, management will wish to scale back consumption dramatically in order to cut costs.[102]

A study by SEVEn,[103] the Energy Efficiency Center in Prague concludes that 701 PJ [104] (more than eight times the amount required to replace nuclear power) may be saved every year with retrofitting in particular industries. The retrofitting of furnaces alone is projected to save 259 PJ/year, while efficiency improvements in secondary energy sources contribute an additional 350 PJ/year. Decentralizing the electricity production system will help minimize waste. The use of small cogeneration plants (according to the SEVEn study, current technology makes possible units of approximately 100 kW).[105] In addition, larger-scale cogeneration technologies, which involve the backfitting of plants to support combined heat and power production, require little start-up time and can use indigenous production facilities.[106] As a final improvement in the electricity generation industry, old plants in Slovakia could be upgraded. Particularly, improving the efficiency of three fossil fuel powerplants from 30 percent to the western level of 42 percent would save approximately 800 MW, and would allow the closure of 2 reactors in Bohunice.[107]

The state has already begun to consider some of these options. CSFR has begun to study efficiency alternatives, while the utilities in both the Czech and Slovak republics have begun to study least-cost approaches to planning in electricity generation and distribution. These approaches emphasize energy efficiency as a more economical approach to power generation.[108] The total savings in the industrial sector is estimated to be one-third of total energy consumption.[109] This exceeds the level of savings necessary to shut down every nuclear plant.

These estimates include only the industrial sector; the residential sector provides new opportunities for energy efficiency. Although industrial energy prices approach those of Western Europe, prices in the residential areas are two to three times

cheaper than in Western Europe. However, since CSFR salaries are at least ten times lower than those in Western Europe, there still exists a strong comparative incentive for households to save energy. Information dissemination to households could help encourage this process, and help make the demand for energy more responsive to price increases. This could also help overcome "the most formidable barrier". The SEVEn study concludes: "As long as the average citizen persists in thinking that the value of energy savings is as an emergency measure taken by those who do not have enough money for energy, [there] is no hope for the success of energy conservation.[110] People must then be convinced that the future of their economy and their environment lies in energy efficiency.

b. National Energy Policy

The Federal Government, in anticipation of the economic transition, has formulated the Federal Energy Policy, which will guide energy use and production in the next decade. That policy places a high priority on the cleanup of CSFR's devastated environment. The use of clean-burning fuel should help address this concern; natural gas use is projected to rise by 5 percent of total energy consumption in the next decade.[111] Expansion in these industries, along with the development of cogeneration technology will allow CSFR to meet its emissions targets without the use of nuclear power.

C. The Former Soviet Union

1. Energy Demand

a. Energy Prices

In the past, energy prices in the Soviet Union have remained stable—untouched by the fluctuating prices of the world market. Domestic energy prices were determined by the State Pricing Committee every 11–14 years and "have been set without any mechanism to tie domestic energy prices to world market prices" [112] As real energy prices increased, Soviet energy prices failed to do so and as a result, "Soviet energy costs have moved further and further away from energy prices." [113] This low cost of energy gave the Soviets little incentive to save energy; in addition, because energy was allocated on a quota system, to use less energy resulted in the penalty of being allocated less energy. Therefore, the system itself encouraged waste.

To lessen this existing gap, liberalization of energy prices has been a goal in the "Main Directions of Economic Policy for Russian Federation." In May 1992, the Russian government stepped toward this goal by increasing energy prices 5–7 fold. Price growth will reverse the cycle which has inevitably led to the devaluation of energy. Enterprises are receiving the message that "the time of wasteful energy utilization is over;" [114] as energy prices continue to rise, consumers will meet the rise through conservation. In order to allow consumers to respond to this decrease in price, the international community should provide conservation information and technology, as loans or as aid, to end-users of energy.

b. Industry

The industrial sector of the Soviet economy has been a large consumer of energy, "accounting for 50 percent of final energy consumption" [115] "Large-scale development projects for industrial production, construction, and agriculture" [116] were the target of the first Five-Year Plan and have in large part led to such a high rate of consumption by industry. Because industry is a major consumer of energy, "most Soviet articles on conservation often focus on the potential for reducing the demand for energy by industry." [117] The reduction of energy use by industry should be focussed on moving away from such energy-intense heavy industrial production and moving toward the production of "less energy-intensive goods." [118] Technological change and "behavioral change in managing factories" [119] are also both important components of energy conservation in the industrial sector.

c. Transportation

The transportation sector of the former Soviet Union is becoming increasingly more important. Freight activity and collective transportation have dominated the travel industry in the past and still continue to do so, but travel by air and private auto is becoming more popular. Structural and technological changes in the transportation industry could lead to greater energy efficiency.

As the economy contracts, the amount of freight activity will subsequently decline. However, autonomous republics will "produce more local specialization and inter-republic trade." [120] With this substitution in output, "the role of the trucks will likely increase" [121] with the increase in food and consumer goods. To increase

the energy efficiency of the economy, the international community should encourage the maintenance of freight and collective transportation, to alleviate the need for wasteful vehicles likes trucks and personal autos.

d. Residential

The residential sector of the former Soviet Union uses appliances sparsely, but inefficiently. Simply implementing "more efficient energy use could reduce energy intensities significantly." [122] Because economic expansion will increase demand for home appliances in the future, such appliances must become more electrically efficient in order to hold total electricity demand in check. Offsetting this projected increase, however, is the much improved efficiency of modern Soviet-made appliances.[123] Technical assistance could encourage this trend and help prevent a significant increase in home electricity consumption.

2. Conservation Technologies

Electric drives consume 60 percent of the electricity of the Soviet Union. The majority of the drives used are low-voltage drives which are inefficient in comparison with frequently regulated electric drives (36 percent more efficient than the low-voltage drives). Using the more efficient regulated electric drives "will allow a 60 percent reduction of electricity used by these devices. . . and can also increase the longevity of the equipment and regulate energy use." [124] The international community should import "equipment to produce drives domestically (and) install controlled electric drives in a wide range of industries." [125]

The lighting systems in the former Soviet Union are insufficient and leave much room for improvement. Simply by using more energy-efficient lighting, the former Soviet Union could save 20 GW [126] (20,000 MW) of energy. In the United States, use of compact fluorescent lamps (CFLs) has become popular. CFLs "provide the same light as incandescent lamps with one-fourth as much energy." [127] Replacing incandescent lights in the former Soviet Union with CFLs would save a significant amount of energy.

Alternatives for lighting also include "a new generation of efficient tubes [which] offer a 10 percent savings in commercial buildings plus substantially better color quality." [128] A 50 percent savings can be reached by merely "running these lamps with efficient electronic ballasts. . . cleaning dusty and yellowing features and sliding a simple aluminum reflector behind the lamps." [129]

The international community should encourage replacement of present lighting systems by assisting in the building of CFL factories or providing the former Soviet Union with CFLs. The benefits of the investment this will produce far outweigh further investment in nuclear technology; the "$7 million cost of a CFL factory is trivial compared to the cost of the powerplant it replaces." [130]

Considering all these specific improvements, among others, Russian scientist Igor Bashmakov argues: "In 1990 the former USSR had 37 [131] GW capacity of nuclear power stations. . . It is clear that these reactors could be decommissioned as more stress on improvements of electricity utilization efficiency . . . would be made." [132] Bashmakov estimates that an average direct investment of only $2.90 for every barrel of oil equivalent per year would save, by the year 2005: 150 million t of coal; 70 million t oil; 250 billion m^3 of natural gas; 400 billion kWh electricity. Indeed, given a nuclear capacity of 2.8×10^8 MWh, the electricity savings of 4×10^8 MWh would more than replace losses from nuclear plants, even absent the projected reductions in other primary energy use.[133] In the short-term, approximately 8–9 GW of nuclear capacity would have to be replaced, through a combination of industrial and residential retrofitting, electrical cogeneration, and other short-term conservation technologies.

3. Energy Supply

a. Electricity Generation

Since 1989, growth in electricity generation has decreased from a 4 percent growth rate in 1989, to a 1 percent growth rate in 1990. A shortage of electrical generation will result in a "supply demand gap. . . with increased likelihood of power shortages and 'black-outs.' " [134] The problem can be solved, safely and efficiently, by upgrading the electrical generation industry to use improved efficiency gas turbines and cogeneration facilities.[135]

In addition, the electricity grid has been hurt by the unavailability of nine (out of a total of fifteen) RBMK reactors throughout the former Soviet Union.[136] These reactors have all been temporarily shut down.

b. Renewable Energy

As a start to a long-term strategy dedicated to renewable energy, governments should invest in small-scale hydro, biomass, and wind energy. This would provide an estimated 1500 MW of capacity, which would produce 5.25 TWh/year at 40 percent capacity. As the indigenous industry starts to develop, further capacity increases would be possible. This program would cost between $1.14 [137] and $1.68 billion.[138]

c. Gas

Gas production has increased over the past years but this growth has begun to slow down due to problems within the infrastructure of the industry.[139] Since the problem lies within the infrastructure and clean gas is abundant in the former USSR (although pipes need to be upgraded), the gas industry can be further developed as a last resort,[140] in the unlikely event that conservation and renewable technology fail to compensate for the loss of nuclear energy.[141]

d. Oil

In 1989 oil production fell 2.6 percent from the output of the preceding year and has continued to decline into the 1990's. "The inadequate rate of new discoveries; the smaller size of these new discoveries and the premature decline in production from existing large oilfields" [142] partially explain this decrease. In addition, the lack of foreign exchange has cut off the supply of imported equipment—"for the last three years there was no new oil field developed and presently 22,500 oil wells are out of operation partly due to lack of equipment to repair them.[143] This trend should be allowed to continue as part of a sound energy strategy, in order to decrease the pressure on this nonrenewable resource; to facilitate this decrease, oil must be used more efficiently. Efficiency could be encouraged through conservation, and through the use of oil in electricity, where suitable and efficient.

D. Alternative Backfltting

If conservation and related cogeneration technologies fail to provide adequate power, newer nuclear plants could be backfitted to produce natural gas. As noted earlier,[144] Russia has already begun to backfit partially constructed nuclear plants for the use of natural gas, and another, at Voronezh, is also being retooled, at modest conversion costs. Gas is plentiful in the Soviet Union,[145] and makes up approximately one-fifth of energy production in Hungary and 15 percent in CSFR.[146] Bulgaria imports most of its gas from reserves in Western Siberia.[147]

V. CONCLUSION

The nations of the former Eastern Bloc have already suffered enormous amounts of ecological devastation. The goal of a rational energy policy for these countries must be to minimize environmental impact while still providing for the needs of people. Nuclear power, with or without massive and long-term Western aid, remains too risky to human health and the environment to serve as the basis for a sound energy strategy.

Only conservation and alternatives to nuclear power can satisfy the basic needs of the people while respecting the environment. The nations of Eastern Europe and the former Soviet Union hold much untapped potential for conservation; that potential can be obtained at low ecological and monetary cost. Conservation should be complemented by the pursuit of safe and sustainable supplies of energy, with the most emphasis on renewable energy technologies, and some emphasis on clean-burning fossil fuels like natural gas. Abandoning the pursuit of nuclear energy in these countries will save money, nonrenewable resources, and life.

Friends of the Earth calls on the G–7 Governments and funding agencies to accept this challenge, and to bring their collective resources to bear as a matter of urgency. A collaborative international partnership is required to address the threats posed by these nuclear facilities and to pay for their closure. Likewise, concerted action by the G–7 and their principal funding agents such as the World Bank is essential to success in making the right investments for a sustainable future. This is not the time for timid, tepid responses.

FOOTNOTES

[1] The map at the end of this Report shows the location of each reactor in the region by type and number.

[2] Within a period of 3 months, or as soon as sufficient cogeneration and conservation capacity comes on-line to substitute. As shall be argued, cogeneration and many conservation measures can be developed in the very short-term.

[3] Because closing costs will involve mainly technical assistance and a scant amount of technology, financial aid will not be an extremely significant part of this somewhat inexpensive step. Decommissioning costs would appear in the long-term, and would be more significant.

[4] These reactors should be shut down at a lower priority than the RBMKs, and should be given a phase-out period of 6 months to a year, in order not to shock the grid too heavily.

[5] This figure includes Kozloduy 1 and 2, both temporarily shut down. Kozloduy units 1–4, according to the Cousteau study, among other sources, represent the most immediate risk, because they am VVER 440/230 types. Reactors Sand 6 are third generation 1000 MW plants, and are in slightly better condition. Those plants should be closed within five yearn, to allow energy efficiency and grid improvement to absorb the impact of the decreased energy supply.

[6] According to the study by SEVEn, the Prague, CSFR, center for the study of energy efficiency, industrial retrofitting could substitute for these reactors in the immediate term.

[7] To close down all four reactors at once would shock the electricity supply too heavily, as Hungary probably could not implement compensatory measures quickly enough. As Thomas Jaszays study of efficiency in Hungary indicates, however, 700 MW of cogeneration capacity could be developed in the immediate term; this would compensate for the loss of the first two reactors. Although there is no significant difference in risk between the first pair and the second pair, reactors 3 and 4 may have to be kept open in order to avert a catastrophic power shortage. The remaining two reactors can be shut down within 2 years. This will require a concerted effort to reduce demand through the funding of conservation, as documented by Jaszay, and the longer-term expansion of cogeneration capability. The declining Hungarian energy demand, fostered by restructuring, will buffer the shock of decreased supply.

[8] Andrew Fisher. "Gaping Holes in the Safety Net." *Financial Times:* 1 April 1992.

[9] Juliet Sychrava. "Closure of Soviet Reactors Urged." *Financial Times:* 25 March 1992.

[10] Nicholas Lenssen. Worldwatch Institute. Phone Interview. 25 June 1992. Simon Rippon. "After Five Years, Uncertainties Remain at Chernobyl." *Nuclear News.* June 1991. p.49.

[11] Greenpeace document on Soviet-designed nuclear plants. Fax from Antony Froggatt, Greenpeace U.K., dated 26 June 1992.

[12] Fisher.

[13] Nicholas Lenssen. Worldwatch Institute. Fax dated 30 June 1992.

[14] Fisher.

[15] Sychrava.

[16] Mark Hibbs. "Siemens Reckons up to $12-Billion Needed from G–7 for Eastern PWRs." *Nucleonics Week:* 14 May 1992, p.3.

[17] Hibbs, 2.

[18] The Safety of Nuclear Power Plants in Central and Eastern Europe: An Overview and Major Findings of the IAEA Project on the Safety of WWER 440 Model 230 Nuclear Power Plants. Undated. p.2.

[19] Unless otherwise noted, all data are from IAEA report.

[20] John Willis. *Risk Finance: Backfit vs. Shutdown of WER Nuclear Reactors.* Greenpeace International: Amsterdam, 1991.

[21] Greenpeace document on safety of Soviet-designed reactors. In fax from Antony Froggatt, Greenpeace UK, dated 26 June 1992.

[22] Willis, 13.

[23] Willis, 7.

[24] Round Table 1990—seven person working group of the Greifswald reactor. Drawn up on behalf of the Central Round Table in Berlin, May 1990. Paraphrased in Greenpeace document on safety of Soviet-designed reactors. In fax from Antony Froggatt dated 26 June 1992.

[25] *Environmental Issues.* 11 October 1991.

[26] Willis, 9–14.

[27] It is important to note that Western standards also suffer from many inadequacies and pose their sham of danger to human health and the environment. Nothing in this Report should be construed to support nuclear power as managed and promoted in Western countries.

[28] As quoted in: Christopher Flavin, et al. *The World Nuclear Industry Status Report: 1992.* May 1992. Worldwatch Institute, Greenpeace International, WISE-Paris. p.10.

[29] According to Emil Bedi, energy expert at SZOPK, this reactor does have a containment vessel, which represents the most significant improvement over the 213. According to Bert van Pinxteren, of the FOE International Secretariat, modifications to the containment system am being proposed to enable it to withstand higher pressures.

[30] Permanent Monitoring Group on Plant Safety. *Control Report No. 13.* November 1988. aqi Greenpeace document on Soviet reactor safety, in fax from Antony Froggatt, Greenpeace UK, dated 26 June 1992.

[31] The interior skin of the vessel is 8 mm, and made of steel. Including vessel shielding, the design has 120 mm of steel. Data from *Gefahrenpotential des Atomkomplexes Temelin,* June 1988, sterreichisches kologie-Institut fr angewandte Umweltvorshung.

[32] Willis, 11.

[33] *Permanent Monitoring Group on Plant Safety: Control Report No. 13.* November 1988. As quoted in Greenpeace document on Soviet-designed reactor safety. In fax from Antony Froggatt, Greenpeace UK, dated 26 June 1992.

[34] *Permanent Monitoring Group on Plant Safety.*

[35] *Strengthening Nuclear Regulation in Russia: A Report on the First Workshop on Nuclear Waste and Safety with the committee on Ecology of the Supreme Soviet of the Russian Federation.* December 15–20,1991; February 3–7, 1992.

[36] IAEA,31.

[37] Matthew Wald. "Ex-Soviets Still Lag in Nuclear Safety, U.S. Finds." New York Times: 23 April 1992.

[38] *Environmental Issues.* 11 October, 1991.

[39] *Environmental Issues.* 11 October, 1991, p.68.
[40] Flavin, et al, 10.
[41] The Cousteau Society. *Nuclear Safety and the Kozloduy Nuclear Plant in Bulgaria: Expert's Report.* February, 1992.
[42] Robert D. Pollard. *Report on the Kozloduy Nuclear Power Plants Units 1-4.* January 1992. p.9.
[43] *Economist.* 28 March 1992. p.50.
[44] Flavin, et al, 14. *Strengthening Nuclear Regulation in Russia,* 11.
[45] Mark Hibbs. *Nucleonics Week.* 14 May 1992. p.2.
[46] Flavin et al, 11. Nicholas Lenssen. Worldwatch Institute. Phone interview. 25 June 1992.
[47] *Strengthening Nuclear Regulation,* 10. These incidents, originally reported by Greenpeace, have now been confirmed by Russian politicians.
[48] Senator Frank Murkowski. Senate Committee on Energy and Natural Resources. Hearing on Nuclear Reactors in Eastern Europe and the former Soviet Union. 16 June 1992. Testimony during the cross-examination of witnesses.
[49] Nicholas Lenssen. "Nuclear Waste: The Problem That Won't Go Away." *Worldwatch Paper 106.* December 1991. Worldwatch Institute. p.15.
[50] *Strenghtening Nuclear Regulation,* 8.
[51] Willis, 14.
[52] Except where noted, all factual data is taken from Worldwatch Institute (Washington, DC) Nuclear Power Files, courtesy of Nicholas Lenssen.
[53] *Strengthening Nuclear Regulation.*
[54] Honza Bemnek. World Information Service on Energy. Fax dated 30 June 1992.
[55] Emil Bedi (see note 29). In electronic mail from John Hontelez, dated 28 June 1992.
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[57] *Strengthening Nuclear Regulation.*
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[59] *Strengthening Nuclear Regulation.*
[60] Anatoly Vefflin. "Russia Orders Resumption of its Nuclear Program." Reuters Information Services. June 2,1992.
[61] From Kevin McCann, Petroleum Economics, Ltd. Fax dated 22 June 1992.
[62] IAEA Newsbriefs 7:2. April/May 1992. p.54.
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[65] Mark Hopkins. *Business Opportunities in Eastern Europe for Energy-Efficient Industrial Products.* January 1992. The Alliance to Save Energy. p.30.
[66] Gregory Hats. "Energy Options for Hungary." *Energy Policy.* November 1991. p. 862.
[67] Kats. Barner, Brown, and Foltanyi.
[68] Mark Hopkins. *Business Opportunities in Eastern Europe for Enemy-Efficient Industrial Products.* January 1992. The Alliance to Save Energy.
[69] Hopkins, 21.
[70] Kats, 864.
[71] Kats, 863-4.
[72] Kats, 864.
[73] Marousek, 16. Externality analysis ours.
[74] Kats.
[75] Since Hungary does not have a uniquely cheap supply of energy, it does not make economic sense for its industries to be tilted toward energy consumption. This distribution decreases its overall competitiveness.
[76] Barner, Brown, and Foltanyi, 9.
[77] Barner, Brown, and Foltanyi, 11-2.
[78] This capacity figure, along with all the capacity figures in the report, is an overestimate, because it ignores transmission losses. According to Dr. Robert Pollard of the Union of Concerned Scientists, this inflates the production figure by approximately 5 percent. However, since some energy demand estimates already account for this figure, and since its calculation opens a new realm of dispute, these figures were left as overestimates.
[79] Calculated by Darius Lakdawalla, by multiplying cumulative load factor by net capacity in MW. Based on figures in *Nuclear Power Reactors in the World.* April 1992. International Atomic Energy Agency.
[80] Kats, 859.
[81] All conversions from MW to PJ done by Darius Lakdawalla at FOE-US, by first converting to MWsec (multiply by 31,536,000 sec/yr), then Wsec (10^6 WI MW), then using the identity 1 WI J/sec. That figure then was converted to PJ (1 PJ = 10^{15} J). According to Dr. Robert Pollard, the conversion factor comes out to 1 MWh = 3.6×10^9 J.
[82] Kats, 862.
[83] Barner, Brown, and Foltanyi, 7.
[84] Kats, 859.
[85] Kats, 861. Based on a World Bank lending program (from 1983 to 1988) handled by the National Bank of Hungary and the Energy Supervision Institute.
[86] Kats. Barner, Brown, and Foltanyi.
[87] *IAEA Newsbriefs* 7:2. April/May 1992. p.54.
[88] Calculated by Darius Lakdawalla, using load factor to 1990, and net generating capacity. Data from *Nuclear Power Reactors in the World.* April 1992. IAEA. p. 19.
[89] Hopkins, 30.

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[90] Hopkins, 30.
[91] Calculated by Darius Lakdawalla, FOE-US. Data on long-term load factor and net generating capacity from *Nuclear Power Reactors in the World.* April 1992.
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[93] AID invested in a total of 48 plants throughout Eastern Europe, in the nations of Hungary, Romania, Bulgaria, Poland, and Czechoslovakia.
[94] Given an initial cost of $77,837, and a total estimated savings per year of $262,598.
[95] Hopkins, 19.
[96] See p.11.
[97] M. Bafflerger. *Power Generation and Transmission in Eastern Europe: The Outlook for Nuclear Power in Eastern Europe.* Conference in Brussels, June 1992. Electricite de France International.
[98] MW to PJ conversion calculated by Darius Lakdawalla at FOE-US (see note 81).
[99] Marousek, 4.
[100] Hopkins, 28. Honza Bemnek. World Information Service on Energy. Fax dated 30 June 1992.
[101] Marousek, 3.
[102] According to Emil Bedi (see note 29) the rising cost of energy will make inevitable the restructuring of industry away from energy-intensive endeavors.
[103] Separate studies have corroborated these conclusions in large part. According to Emil Bedi (see note 29) a government study revealed a potential for energy conservation of over 20 percent, while an independent study by the World Wildlife fund estimated a potential of over 40 percent.
[104] Study calculates amount of energy that would have been saved if efficiency measures had been in place in 1991.
[105] Marousek. 6, 13.
[106] Emil Bedi (see note 29). Paraphrased in electronic mail from John Hontelez, dated 28 June 1992.
[107] Emil Bedi (see note 29). Contained in electronic mail message from John Hontelez, dated 28 June, 1992.
[108] Marousek, 15.
[109] Marousek, 5.
[110] Marousek, 15.
[111] Marousek, 13.
[112] R.C. Cooper and L. Schipper. *Energy Use and Conservation in the U.S.S.R.; Patterns, Pros-* [illegible] nce Division, April 1991, p.3.

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[39] *Environmental Issues.* 11 October, 1991, p.68.
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[74] Kats.
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[118] Cooper and Schipper, 26.
[119] Cooper and Schipper, 26.
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[132] Bashmakov, 5.
[133] Conversions to MWh performed by Darius Lakdawalla at FOE-US: original data were multiplied by 1 MW/1 000 kW (which equals 1).
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[137] Based on costs of $757-$1 177 per kilowatt installed.
[138] Stewart Boyle. *Greenpeace Emergency Plan for Immediate Shutdown of RBMK Nuclear Reactors.* Undated. Greenpeace International.
[139] McCann, 365.
[140] McCann, 369.
[141] The problem in the Soviet energy sector is not one of too little supply but of too much demand, relative to economic welfare. The goal of the former Soviet Union should be to decrease energy demand and to minimize the amount of non-renewable resources extracted.
[142] McCann, 368.
[143] Bashmakov, p.3.

[144] See p. 16.
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